CANBERRA 81-82

SERIES 80 MULTICHANNEL ANALYZER
CANBERRA
SERIES 40 MCA
CANBERRA
MULTICHANNEL ANALYZER
SERIES 30
RATEMETER

Canberra Industries, Inc. 45 Gracey Ave. Meriden, Connecticut 06450 Tel. 203-238-2351
TX: 643251 TWX: 710 461 0192 CABLE: CANBERRA

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WORLDWIDE SALES OFFICES

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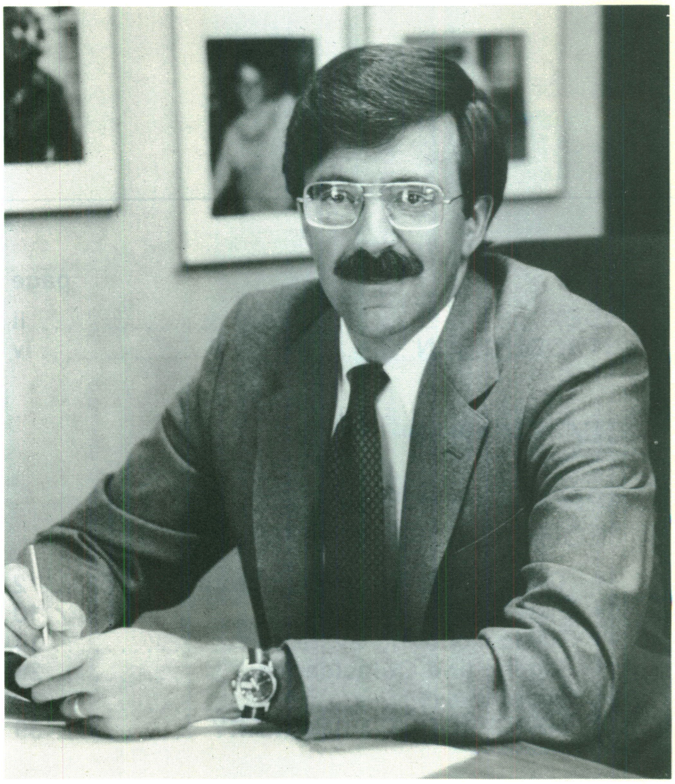
CANBERRA INDUSTRIES, INC.

Canberra Industries was formed in 1965.Then it was little more than an electronics job shop in the nuclear instrument marketplace. Today, Canberra is the largest supplier of nuclear instruments in the world, and operates the largest independent clinical laboratory in the State of Connecticut. We have accomplished much during the 70's, and we have exciting and ambitious plans for the future. This is our story— who we are, how we got here, and where we are going.

In the beginning the nuclear physics research community was our primary marketplace. Instrument flexibility and variety were required if our customers were going to continue advancing the state of their art. We responded agressively; by the late 1960's we offered scores of NIMs, and also solid state radiation detectors. By 1970 we were the second largest NIM supplier in the world, and a major factor in the detector marketplace.

Launching the 70's, Canberra instituted a focused growth plan within the nuclear instrument field. We sensed that our customers would need complete problem solving systems. As the first step, we acquired the Geoscience Multichannel Analyzer line and quickly developed a broad line of advanced multichannel analyzers to complement our detectors and NIMs. Next, we began a program of investments into rapidly growing overseas markets by establishing joint ventures in Germany, England and the Benelux countries, and by securing long term trade agreements with established nuclear suppliers with strong customer service records. Our strategy worked and the company fared well in the 70's. Customers liked our products. Over the past decade we grew at 25% annually in sales and profits. Today we are financially strong, self sufficient, and able to internally finance our growth.

The 80's will present new and tougher challenges. Canberra is ready. It possesses a young, vital management team eager for tomorrow. It has a track record over the past decade that is the envy of the industry. It has financial strength. We are confident the next fifteen years will be even more exciting than our first.



Emery G. Olcott
President Canberra Industries, Inc.

CAPABILITIES

CANBERRA
SPEED LIMIT
25

Our growth record, management style, and entrepreneurial spirit enable us to attract highly skilled, and motivated employees. A large portion of our personnel are professionals with advanced college degrees in Nuclear Physics, Computer Science, Electrical Engineering, Medicine, Pathology and Business. We provide these professionals, and all of our dedicated employees, with clean and modern facilities. The company now occupies over 200k ft^2 of space in multiple facilities located throughout the world.

The company has always had a tradition of designing its own products. Over the years, we've built a versatile and seasoned engineering team skilled in the design of analog and digital instruments, microprocessor controlled equipment and computer based systems. Our instrument design team has produced over 100 different products for us over the years. Our firmware team has designed three generations of microprocessor-based instruments. We have over ten years of experience in microprocessor-based instruments. We have over ten years of experience in minicomputers and software development. Our software staff has experience in over five computer languages; we've even developed a computer language of our own.

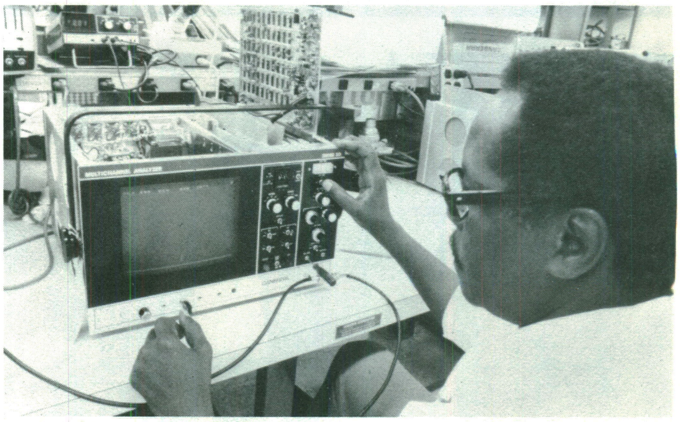
Our manufacturing operation provides the superior workmanship necessary to produce high quality products. We supplement a staff of dedicated employees with automatic equipment for component insertion, wave soldering, printed circuit board testing and instrument inspection. A computerized production control system keeps the product flowing smoothly through the production process. The entire process; sales forecast, product plan, material requirement and purchasing are all monitored and controlled by our on line System 38 IBM computer.

The company has a significant investment in automatic test equipment and computer systems to insure the quality of its products. The instrument division uses minicomputers to evaluate, test and track instrument performance. Quality control and customer service response remain of paramount importance to the company.

SCIENTIFIC INSTRUMENTS

Our largest market is the Scientific Research Community. People involved in nuclear physics research, nuclear medicine, materials analysis, radiopharmacology— all have the need for sensitive, precise instruments to measure gamma rays and x-rays. From gross radiation counting to the precision of germanium based radionuclide analysis, Canberra has been the leader with a steady stream of innovative products.

We offer a variety of detectors for gamma ray measurement. We have been manufacturing lithium drifted germanium (Ge(Li)) detectors for over ten years, and recently began production of high purity germanium detectors. We recently acquired Berkeley Germanium Corp., a producer of hyper pure germanium material.



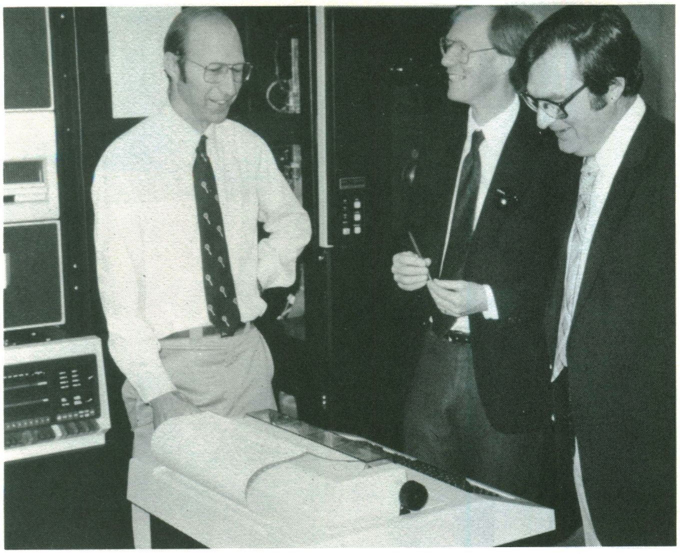
Our Nuclear Instrument Modules were the first products designed by our engineering team 15 years ago. Staying ahead of the competion in the NIM area is a tradition that still drives the management of the Company today. The company enjoys a reputation for developing the best amplifiers in the world.

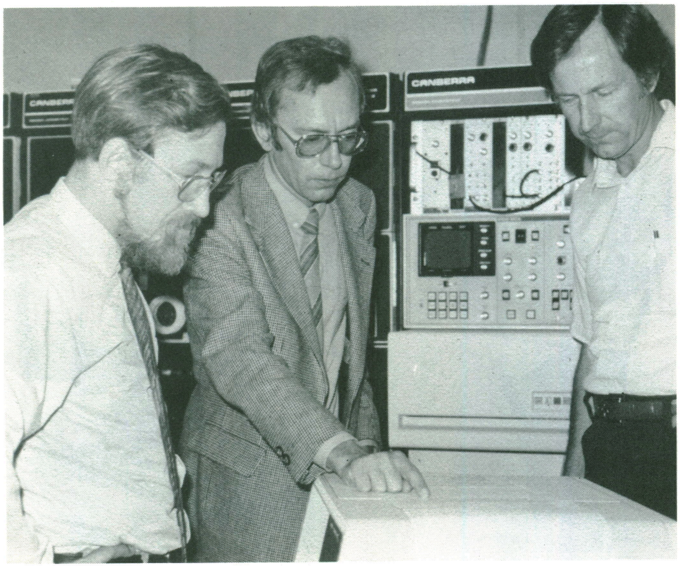
We acquired our first Multichannel Analyzer product when we purchased Geoscience, a spin off of Technical Measurements Corporation. Since then, we have designed several generations of MCA's and now offer the widest product line in the industry. Our inexpensive Series 30 is the most popular MCA ever sold, our Series 80, the most sophisticated. The brand new Series 40 is the latest in microprocessor technology; we predict it will become a standard instrument for all research laboratories.

To back-up these products we have a dedicated Applications Engineering group to insure that complete "Problem Solving" systems can be provided. Many of our customers need to couple the sensitivity of our instruments to the analysis capability of the computer and we have over ten years of experience in computer based systems to help them.

Through our products, we have an ongoing commitment to the Scientific Community. We are dedicated to serving our customers before and after the sale.

NUCLEAR REACTOR MONITORING





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Over ten years ago, we installed our first computerized radionuclide identification system in the Maine Yankee Atomic Power Plant. Today, we have over 300 systems installed— in over 55 countries on six continents— for radionuclide analysis, low level alpha/beta measurements, waste assay, and body burden analysis. Over 75 nuclear power stations throughout the world are using Canberra systems.

We have dedicated a separate division to the development and support of radiation measuring systems for nuclear power plants.

Systems delivered to Nuclear Utilities are supported with:

- Factory-trained Field Service Engineering that provides on-site service, including 24-hour service response.
- Engineering services to provide custom system design
- Project Management services for turn-key installations
- Formal scheduled training programs for operators and technicians offered at convenient locations throughout the world

Our design philosophy considers our present customers as well as our future systems users. We have designed our systems to be generation-to-generation compatible. Put simply, our systems can be upgraded. Our first power plant customer can easily upgrade any part of his system without scraping the rest.

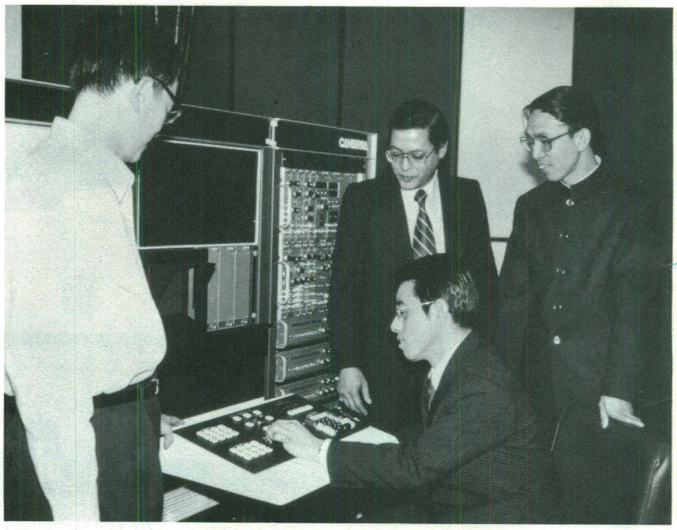
We have built our systems on the strength of two companies. Canberra, largest supplier of nuclear spectroscopy equipment in the world, and Digital Equipment Corporation, the largest supplier of mini-computers, an unbeatable combintation.

WORLDWIDE SALES and SUPPORT

In a rapidly changing, high technology field the effective world-wide distribution of products requires local application support and local service. We feel that one of our greatest accomplishments is the organization we have established to support our products around the world. We have over 70 offices in more than 55 countries....all committed to serving our customers.

We have strategically located our offices, wholly-owned subsidiaries and joint venture companies to insure the most effective geographic support. All of these organizations are managed by nationals, and staffed to provide Sales and factory-trained Customer Service. Many have application engineering, custom software, system engineering, and customer training capabilities. All are devoted to fulfilling the unique needs of their customers.

Our customers around the world demand the same quality of service they would normally receive from local manufacturers; prompt and complete responses to inquiries, reliable deliveries, adequate, reasonable, and timely after-sales service, and that is our commitment.



APPLICATIONS and TECHNICAL REFERENCE 1

This section covers material important for the proper selection of detector and electronics for detection and analysis of X-ray, gamma ray, or charged particle radiation. Canberra Industries has extensive experience in supplying instrumentation for a wide variety of applications, ranging from simple detector to scaler configurations to complex dedicated systems like automatic sample analysis, nuclear waste assay, and body burden measurements. This brief overview emphasizes basic principles; greater detail is found in the introductions to each section, and should be consulted when making purchases. You are also invited to contact Canberra directly for additional information.

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Gamma and X-Ray Detection

INTERACTIONS WITH MATTER

In order to understand the detectors used for gamma and X-ray detection and to be able to select one for a particular measurement, it is necessary to review the ways in which gamma rays and X-rays interact with matter.

There are three principal ways in which the low-energy photons known as gamma rays and X-rays interact with matter. These are:

a. Compton Scattering
b. Photoelectric Effect
c. Pair Production

These processes are strongly dependent upon the energy of the photon and the atomic number Z of the material. Other effects, such as Rayleigh scattering, Thomson scattering, and others are much less important[1] and can be ignored in detection processes.

In Compton scattering the photon collides with an electron, losing energy to the electron and scattering to a different direction. The energy of electron and the scattered photon are given by:

$$E\gamma = E_o\,[1 + (E_o/mc^2)\,(1 - \cos\theta)]^{-1}$$

$$E_e = E_o - E\gamma = E_o \left[\frac{(E_o/mc^2)\,(1 - \cos\theta)}{1 + (E_o/mc^2)\,(1 - \cos\theta)}\right]$$

where E_o is the incident photon energy
$E\gamma$ is the scattered photon energy
E_e is the electron energy
m = electron mass
c = velocity of light
θ = angle between incident and scattered gamma ray directions

The maximum energy loss by the photon is for a head-on collision ($\theta = 180^o$) and is equal to:

$$E_o - E\gamma = \frac{E_o}{1 + mc^2/2E_o}$$

The fractional energy loss of low-energy photons is small since the scattering is nearly elastic, but becomes appreciable at higher energies.

The probability of scattering to a particular angle is a complicated function of energy and angle, but can be generally described as becoming increasingly peaked at small angles as the photon energy increases[1]. The total cross section depends upon the number of electrons available, or as the atomic number Z of the material[1]. The energy distribution of Compton electrons for several gamma ray energies is shown in Figure 1.

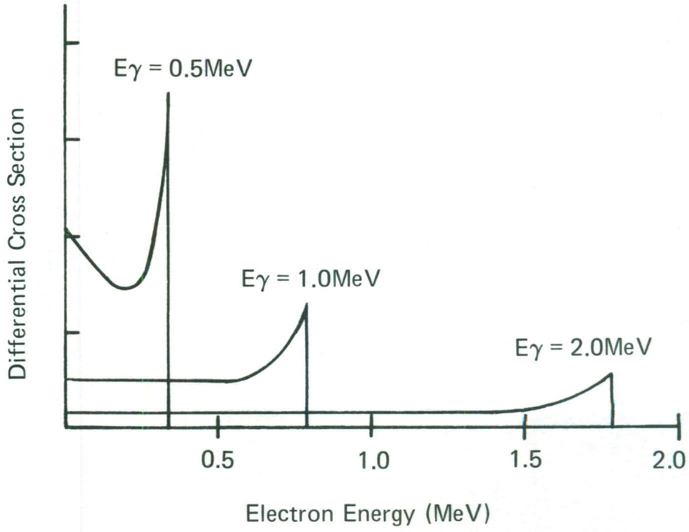


Figure 1. Compton Scattered Electron Energy Distribution.

The photoelectric effect is the process in which a photon is absorbed by an atom and emits an electron (or photoelectron). The electron energy is equal to photon energy minus the binding energy. The photoelectric probability increases strongly with Z of the material, depending upon the Z^4 to Z^5. The probability also is less important at higher energies.

Pair production is the process by which a positron-electron pair is created in the field of a nucleus. The creation of the anti-matter positron is viewed as ejecting an electron from a negative energy state into a positive energy state, leaving a hole in the region of normally filled negative energy states. This hole is the positron. There is a gap of $2m_oc^2$ between the two energy regions, so at least 1.022MeV of energy is required to create a positron.

In summary, all three processes produce moving electrons (or positrons) in matter, which can be detected directly or can initiate other electron processes to obtain an electric charge pulse. At low energies, up to about 100keV (the X-ray region), the photoelectric effect is dominant. Compton scattering varies from a minor effect at 10keV to being more important near 100keV. Up to 1MeV the photoelectric effect is declining in probability and multiple compton scattering effects become important. Above 1.02MeV pair production increases in probability.

The *importance* of these interactions for detectors is in how they relate to incident gamma ray energy deposited in the crystal. An ideal detector converts all of the energy of the gamma ray into an electric pulse that is directly proportional to the gamma ray energy, i.e., linear. For gamma rays the Compton scattering often results in only a fraction of the energy being deposited because the gamma ray can scatter and then escape from the crystal without further interaction. The full-energy peak can be produced by a photoelectric absorption, or one or more Compton scatterings followed by photoelectric absorption.

If pair production occurs, the positron slows down in the material and then annihilates, producing two 511keV gamma rays. Each of these may escape from the detector totally, or leave part of their energy by Compton scattering. If one or both totally escapes the deposited energy is the full energy minus 511 or 1022keV, leading to designation of these peaks as "single escape" and "double escape" peaks. An idealized spectrum from a source of gamma rays at 2MeV is shown in Figure 2.

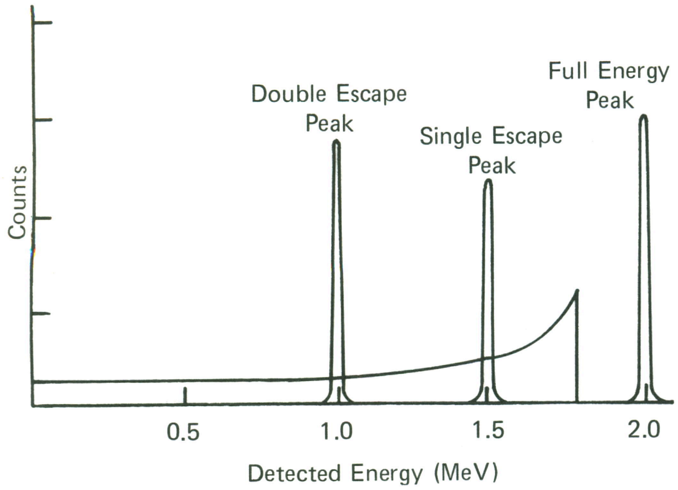


Figure 2. Idealized Gamma Ray Spectrum.

ABSORPTION COEFFICIENTS

The probability of interacting with matter in one of these three processes can be expressed as a cross section or as an absorption coefficient. The absorption coefficient contains the cross section and is therefore more practical in calculating absorption fractions.

The attenuation coefficient for a beam of gamma rays is related to the number of gamma rays removed from the beam, either by absorption or scattering. For the Compton effect, the absorption cross section is determined by the energy absorbed by the electron, which is the total collision energy minus the average scattered photon energy. For all three processes, the total attenuation coefficient μ is the sum of the three partial attenuation coefficients:

μtotal = μphotoelectric + μCompton + μpair production

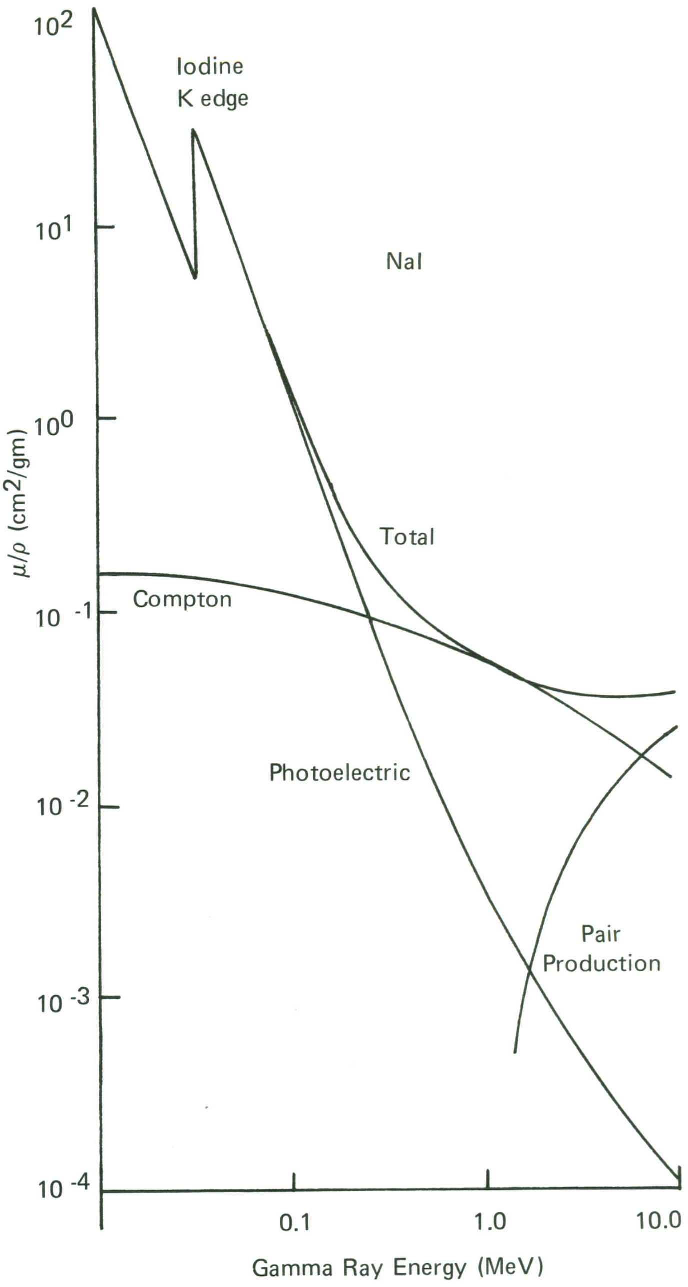


Figure 3. Absorption Coefficients for NaI.

The attenuation coefficients themselves are defined in terms of thickness of material or surface weight of material. This is just using a thickness x (cm) or a surface weight ρx (gm/cm^2) where ρ is the density (in gm/cm^3). The number of primary photons n removed from a beam of n photons is $\frac{dn}{n} = -\mu dx$ which integrates to:

$$n = n_o e^{-\mu x}$$

for an initial beam intensity n_o. For surface density ρx the equation is:

$$n = n_o e^{\frac{-\mu}{\rho}(\rho x)}$$

μ is known as the linear attenuation coefficient and μ/ρ as the mass attenuation coefficient. Graphs of the values [2] for μ for NaI are shown in Figure 3, showing the total μ/ρ value and Compton, photoelectric, and pair production components. Figure 4 shows total μ/ρ values for lead and copper[2]. The K and L edges in the photoelectric absorption are at the energy where the photon can eject a K or L shell electron, thus providing an additional absorption mechanism.

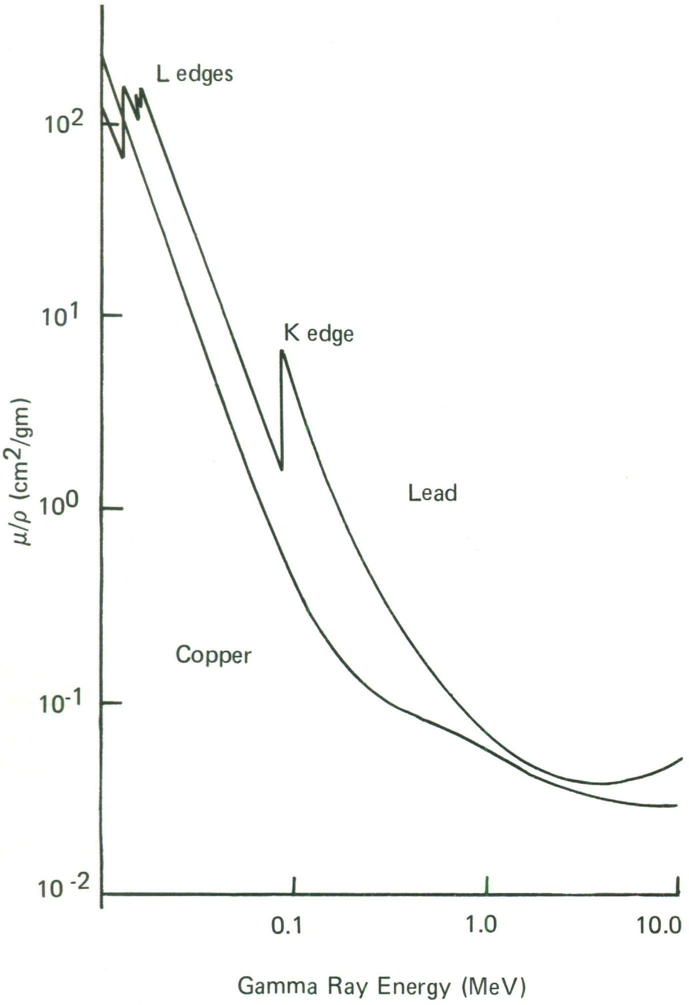


Figure 4. Absorption Coefficients for Lead, Copper.

DETECTOR EFFICIENCY

The efficiency of a detector is a measure of how many pulses occur for a given number of gamma rays. Various kinds of efficiency definitions are in common use for gamma ray detectors:

a. Absolute Efficiency - the ratio of the number of counts produced by the detector to the number of gamma rays produced by the source (into all directions). This includes the solid angle subtended by the detector, thereby depending upon the source-to-detector distance.

b. Intrinsic Efficiency - the ratio of the number of pulses produced by the detector to the number of gamma rays striking the detector.

c. Relative Efficiency - efficiency of one detector relative to another; commonly that of a germanium detector relative to a 3" diameter by 3" long NaI crystal, each at 25 cm from a point source, and specified at 1.33MeV only.

d. Full-Energy Peak (or Photopeak) Efficiency - the efficiency for producing full-energy peak pulses only, rather than a pulse of any size for the gamma ray.

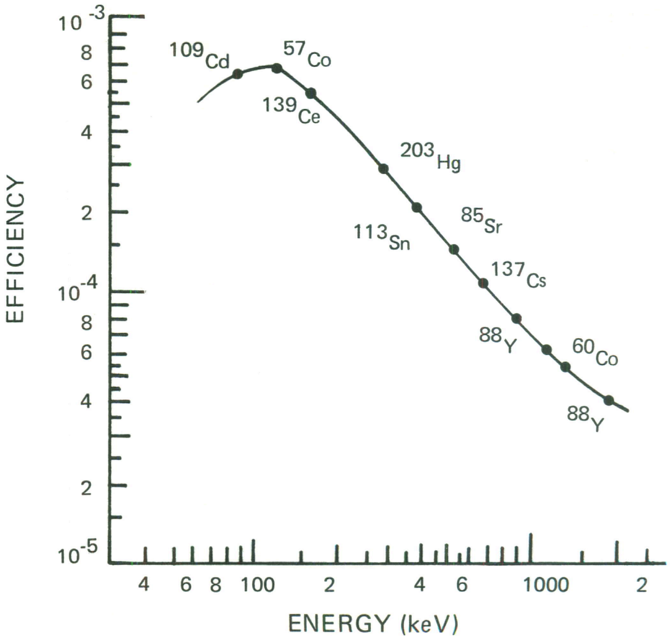


Figure 5. Efficiency Calibration.

All of the above efficiences may be defined for pulses anywhere in the spectrum or for only the full-energy peak. An example of a full-energy peak efficiency curve for a germanium detector is shown in Figure 5.

DETECTOR OVERVIEW

The choice of a particular detector for an application depends primarily upon the gamma energy range of interest. The detector must have sufficient material to absorb a large fraction of the gamma ray energy. Thus, a gas-filled proportional counter is suitable for 14.4keV gamma rays or for X-rays, but would not "see" 1MeV gamma rays because the probability of absorbing the gamma ray energy is too low.

Further, the higher gamma ray energies are more effectively absorbed by higher Z materials. Other considerations are count rate capability, resolution, and if timing applications are involved, pulse rise time. The kinds of detectors commonly used can be categorized as:

a. Gas-filled Detectors
b. Scintillation Detectors
c. Solid State Detectors

Gas-filled detectors are used for X-rays or low energy gamma rays. These can range from ionization chambers to proportional counters to Geiger-Muller counters. Scintillation detectors are used in conjunction with a photomultiplier tube to convert the light scintillation pulse into an electric pulse. Solid crystal scintillators such as CsI or NaI are commonly used, as well as plastics and various liquids.

Solid state detectors are the newest type available, consisting of large crystals of very pure germanium or silicon, in which minor crystal defects or impurities may be compensated by lithium. The superior resolution of these detectors has revolutionized data gathering for X and gamma ray measurements.

GAS-FILLED DETECTORS

A gas-filled detector is basically a metal chamber filled with gas and which contains a positive anode wire. A gamma ray passing through the gas produces free electrons and positive ions by the interactions described above. The electrons are attracted to the anode wire and collected to produce an electric pulse.

At low anode voltages the electrons produced may recombine with the ions and the signal is reduced. Recombination may also occur for a high density of ions. At a sufficiently high voltage nearly all electrons are collected, and the detector is known as an ionization chamber. At higher voltages the electrons are accelerated toward the anode at energies high enough to ionize other atoms, thus creating a larger number of electrons. Over a wide voltage range the output pulse, which is now much larger than for an ionization chamber, is proportional to the original ionization. At higher voltages the electron multiplication is greater yet, and the number of electrons collected is independent of the initial ionization. This region is the Geiger-Muller counter, where the large output pulse is the same for all gamma rays. At still higher voltages continuous discharge occurs.

The different voltage regions are indicated schematically in Figure 6. The actual voltages can vary widely from one detector to the next, depending upon the detector geometry and the gas type and pressure.

IONIZATION CHAMBER

The very low signal output for the ionization chamber makes this detector difficult to use for detecting individual gamma rays. It finds use in high radiation fluxes in which the total current produced can be very large. Many radiation monitoring instruments use ionization chambers. Absolute ionization measurements can be made, using an electrometer for recording the output.[3]

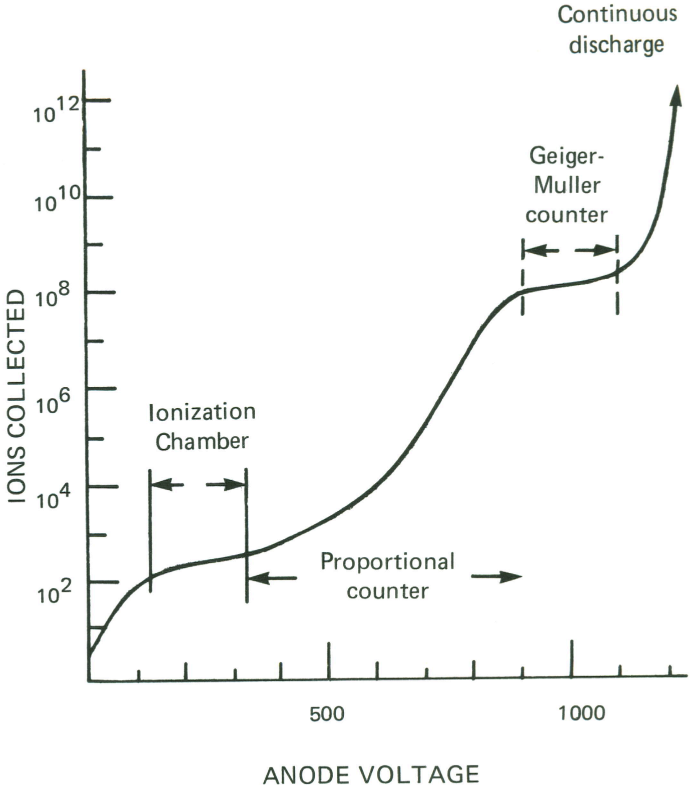


Figure 6. Gas Detector Output vs Anode Voltage.

PROPORTIONAL COUNTER

Proportional counters are frequently used for X-ray measurements where moderate energy resolution is required. A spectrum of ^{57}Co is shown in Figure 7 in which 14.4keV gamma rays are well-separated from the 6.4keV X-rays from iron.

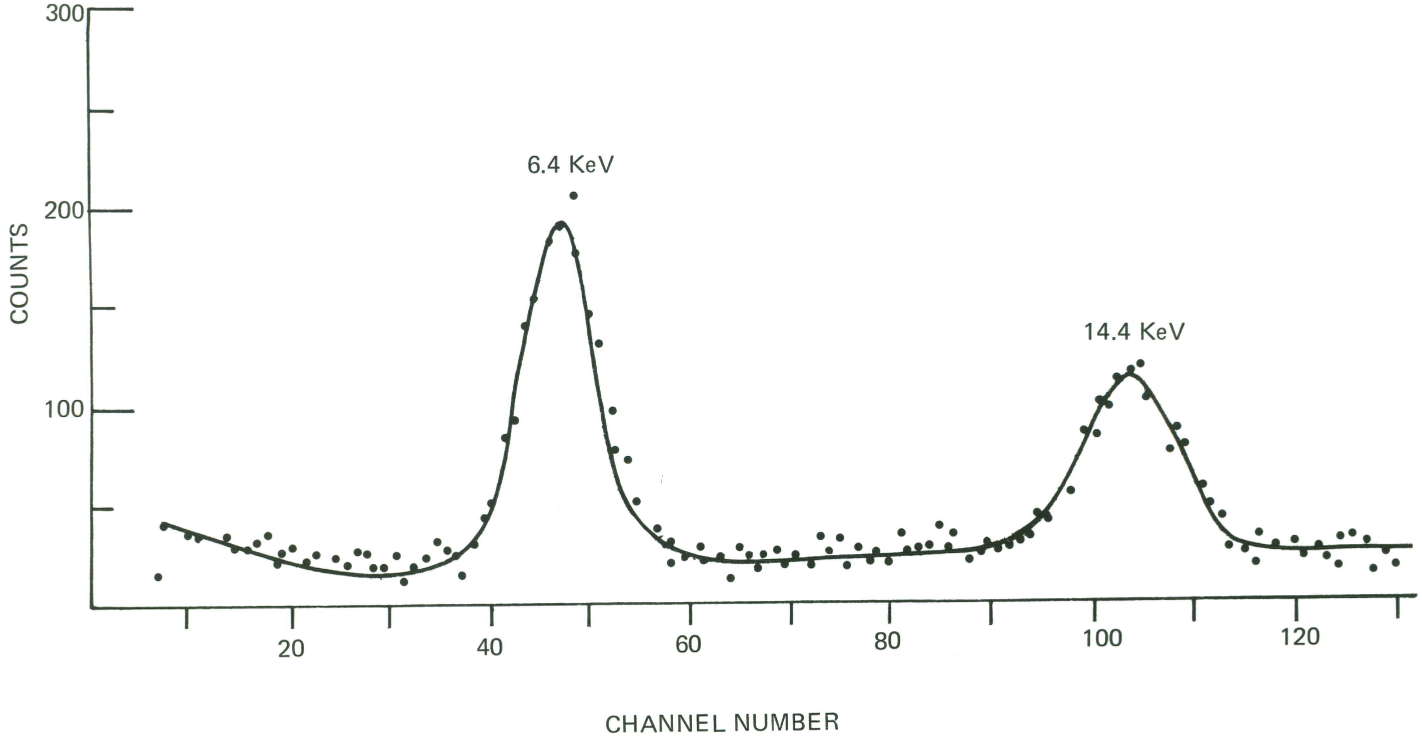


Figure 7. ^{57}Co Spectrum from Proportional Counter.

Proportional counters can be purchased in varying sizes and shapes, ranging from cylindrical with end or side windows to "pancake" flat cylinders. They may be sealed detectors or operate with gas flow, and may have thin beryllium windows or be windowless. A detector is specified in terms of its physical size, effective window size and gas path length, operating voltage range, and resolution for the 5.9keV X-ray from an Fe-55 source (Mn X-ray). Typical resolutions are about 18 to 20% full-width at half maximum (FWHM).

Operating voltages depend upon the fill gas as well as the geometry. The noble gases are often used, with Argon a common choice. Krypton and Xenon are selected for higher energy X-rays or to get higher efficiencies. Neon is selected when it is desired to detect low energy X-rays in the presence of unwanted higher energy X-rays. Gas mixtures are sometimes used, such as 90% Argon, 10% Methane, known as P-10. Gas pressures are typically one atmosphere. The preamplifiers available for proportional counters are shown in Figure 8.

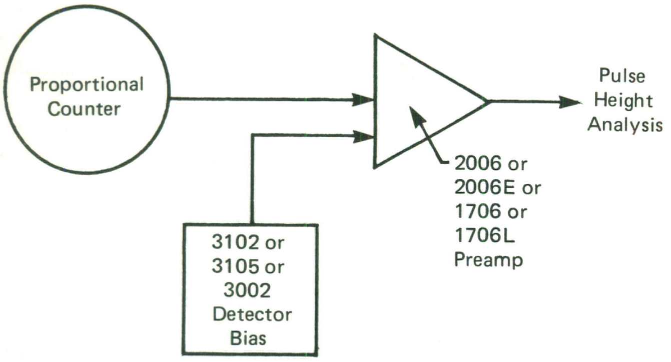

Proportional Counter
Pulse Height Analysis
2006 or 2006E or 1706 or 1706L Preamp
3102 or 3105 or 3002 Detector Bias

Figure 8. Proportional Counter & Preamplifier.

GEIGER-MUELLER COUNTER

The Geiger-Muller counter produces a large voltage pulse that is easily counted without further amplification. No energy measurements are possible since the output pulse height is independent of initial ionization. Geiger-Muller counters are available in a wide variety of sizes, generally with a thin mica window. The operating voltage is in the plateau region (see Figure 6), which can be very flat for a few hundred volts. The plateau is determined by measuring the counting rate as a function of the anode voltage.

The discharge produced by an ionization must be quenched in order for the detector to be returned to a neutral ionization state for the next pulse. This is accomplished by using a fill gas that contains a small amount of halogen in addition to a noble gas. The voltage drop across a large resistor between the anode and bias supply will also serve to quench the discharge since the operating voltage will be reduced below the plateau.

The Geiger-Muller counter is inactive or "dead" after each pulse until the quenching is complete. This dead time can be hundreds of microseconds long, which limits the counter for high count rate applications. The counting circuit for a Geiger-Muller counter is shown in Figure 9.

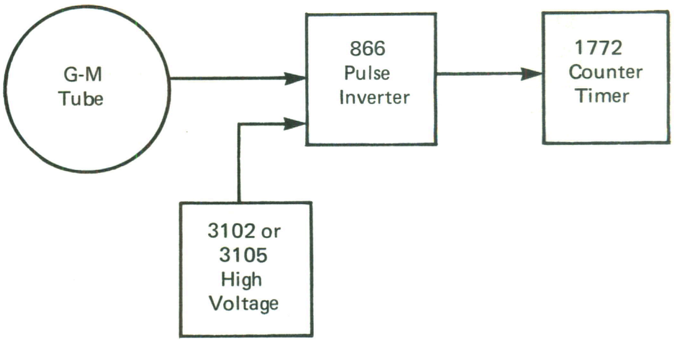


Figure 9. Geiger-Muller Counting Circuit.

SCINTILLATION DETECTORS

The gamma ray interacting with a scintillator produces a pulse of light, which is converted to an electric pulse by a photomultiplier tube. The photomultiplier consists of a photocathode, a focusing electrode and 10 or more dynodes that multiply the number of electrons striking them several times at each dynode. The anode and dynodes are biased by a chain of resistors typically located in a plug-in tube base assembly. Complete assemblies including scintillator and photomultiplier tube are commercially available from Canberra.

The properties of a scintillation material required for good detectors are transparency, availability in large size, and large light output proportional to gamma ray energy. Relatively few materials have good properties for detectors. Thallium activated NaI and CsI crystals are commonly used, as well as a wide variety of plastics. Both NaI and CsI require a small amount of Thallium for proper operation. NaI is the dominant material for gamma detection because it provides much better gamma ray resolution than CsI or plastic. However, CsI and plastic have much faster pulse light decay and find use in timing applications. The actual process by which light is produced is very complex, as can be seen in Reference 2.

NaI SCINTILLATION DETECTORS

The high Z of iodine in NaI gives good efficiency for gamma ray detection. A small amount of Tl is added in order to activate the crystal, so that the designation is usually NaI(Tl) for the crystal. The best resolution achievable is about 7% for the 662keV gamma ray from Cs-137 for a 3" diameter by 3" long crystal, and slightly worse for smaller or larger sizes. Typical spectra are shown in Figure 10 for Cs-137 and Na-22 gamma sources. NaI is slightly non-linear (about 5%) at low energies (below 200keV) because of light output variations with gamma energy.

The light decay time constant in NaI is about 0.25 microseconds. Typical charge sensitive preamplifiers translate this into an output pulse rise time of about 0.5 microseconds. Fast coincidence measurements cannot achieve the very short resolving times that are possible with plastic, especially at low gamma ray energies.

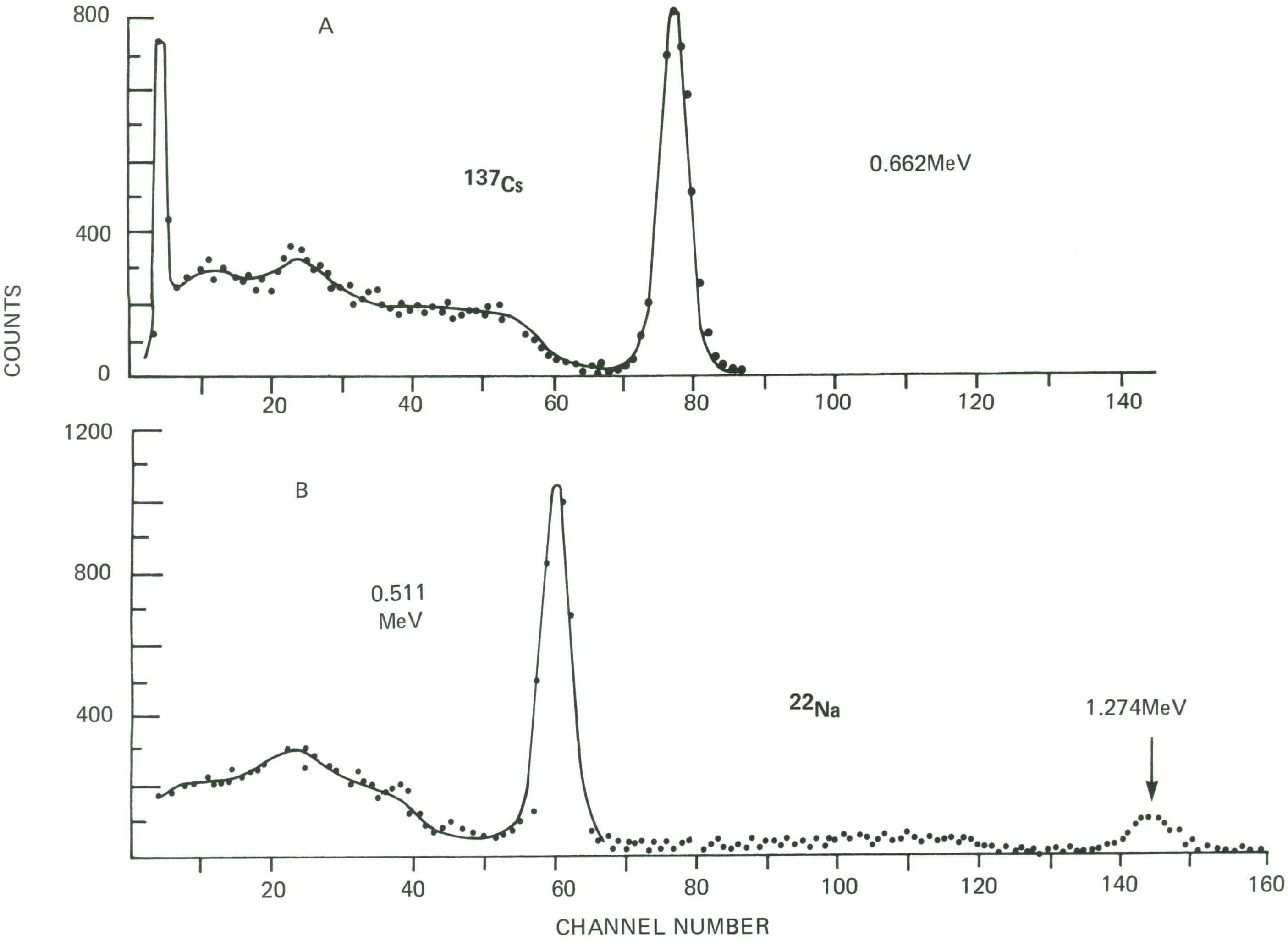


Figure 10. NaI(Tl) Spectra.

Many configurations of NaI detectors are commercially available, ranging from very thin crystals for X-ray measurements to large crystals with multiple phototubes. Crystals built with a well to allow nearly spherical (4π) geometry counting of weak samples are also a standard configuration. Several preamplifier and amplifier combinations are shown in Figure 11.

PLASTIC SCINTILLATORS

Many types of plastic scintillators are commercially available, and find application in fast timing, charged particle or neutron detection, or in cases where the rugged nature of the plastic (compared to NaI) or very large sizes are appropriate. The active component is usually anthracene, mixed in various amounts in a polyvinyltoluene base. Subnanosecond rise times are achieved with plastic detectors coupled to fast photomultiplier tubes, and these assemblies are ideal for fast timing work.

The energy resolution of plastic scintillators for gamma rays is very poor compared to NaI because the efficiency of organic materials for gamma absorption is low (all low Z elements). Separate outputs are usually used for timing, with the positive dynode output to a preamplifier and amplifier for energy analysis, and the larger negative anode output to a fast discriminator, as shown in Figure 12.

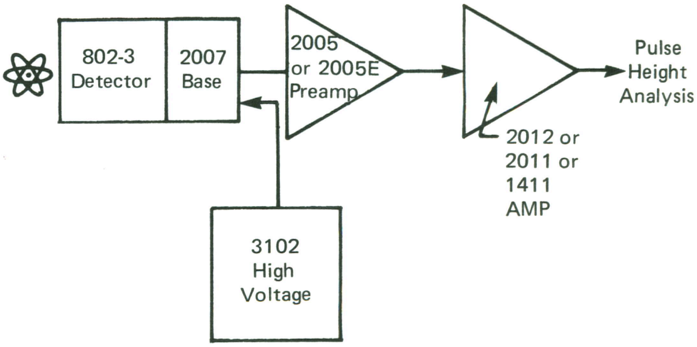


Figure 11. NaI(Tl) Detector Electronics.

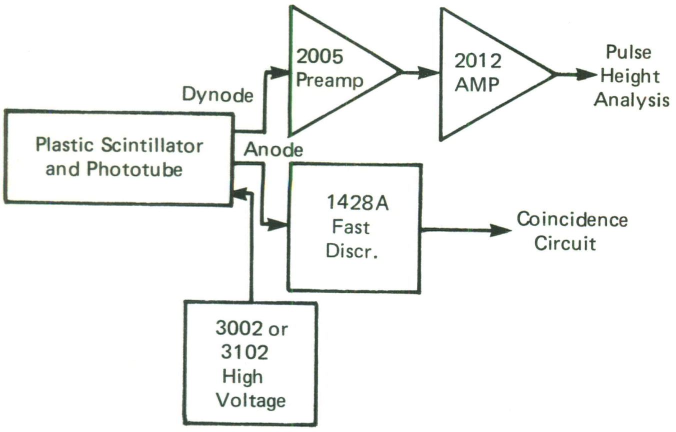


Figure 12. Plastic Scintillation Detector Electronics.

SOLID STATE GAMMA RAY DETECTORS

Solid state detectors are the newest type of detector for gamma radiation, and have the advantage of very high resolution. These detectors are essentially solid state ionization chambers but with the higher efficiency due to a solid rather than a gas. They are made of germanium or silicon crystals. Larger numbers of electrons are produced by a gamma ray because only about 3eV is required per free electron rather than the 30eV required in a gas ionization chamber. A scintillation detector requires 300eV or more per electron.

The detector is a crystal of germanium or silicon that is processed to form a diode. When operated under reverse bias, electron-hole pairs produced by the gamma ray are swept out of the crystal by the electric field. A practical detector requires that other sources of electrons be minimized. This is accomplished in large crystals by compensating for impurities with lithium in a process known as lithium drifting. Lithium drifted crystals, as well as high purity intrinsic germanium that does not require compensation, are operated at liquid nitrogen temperatures to reduce thermal noise. Lithium drifted germanium, or Ge(Li), detectors must be maintained at liquid nitrogen temperatures at all times for the lithium to remain in place, while intrinsic (or pure) germanium detectors can be left at room temperature when not in use. A Model 1786 Liquid Nitrogen Monitor is an important accessory to cooled detector systems.

Two basic geometries are in common use: planar and coaxial. The planar detector is a right circular cylindar with large area and limited depth, and is the only form for Si(Li) detectors. Intrinsic germanium detectors are available as planar or coaxial detectors, and Ge(Li) detectors are available as coaxial detectors. The coaxial detector is a right-circular cylinder with length typically equal to diameter, with a dead central core, as shown in Figure 13. The detection region is the electrically neutral intrinsic region. The core may extend from end to end (true coaxial) or it may go only part way through (closed end coaxial). The closed-end coaxial detector shown provides greater sensitive volume for the same length. However, for timing measurements the charge collection time is somewhat longer because of the non-uniform electric field in the end region.

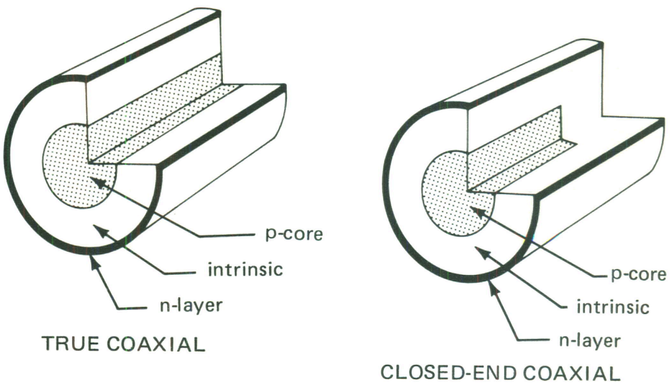


Figure 13. Closed-End Coaxial versus True Coaxial Detectors.

Because of the small volume of Si(Li) and instrinsic planar detectors, these are more suited to X-ray and low energy gamma ray measurements. The resolution of Si(Li) detectors is in the range of 160 to 180eV for the 5.9keV Fe-55 X-ray (Mn K_α X-ray), which is so good that one can resolve X-rays from adjacent elements as low as atomic number 11 or 12 (Na or Mg). The resolution for planar germanium at 5.9keV is slightly better for small diameter detectors and is worse for the larger ones. At 122keV the resolution is about 500 to 600eV. A Si(Li) detector fluorescence X-ray spectrum for Cu, Fe, and Ni (6 to 8keV) is shown in Figure 14.

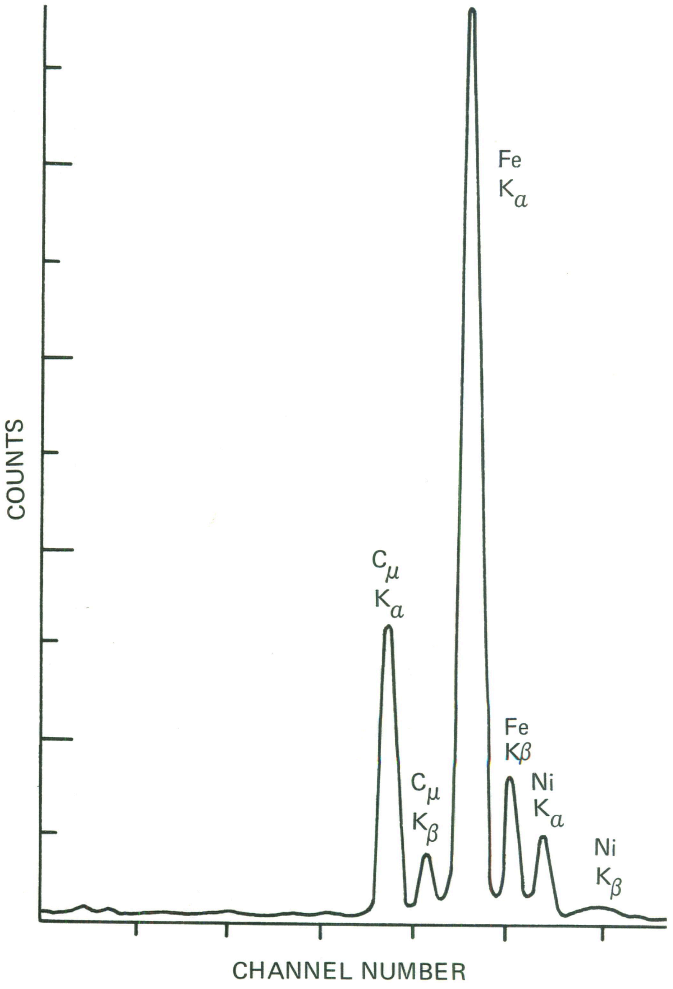


Figure 14. Stainless Steel Fluorescence Spectrum.

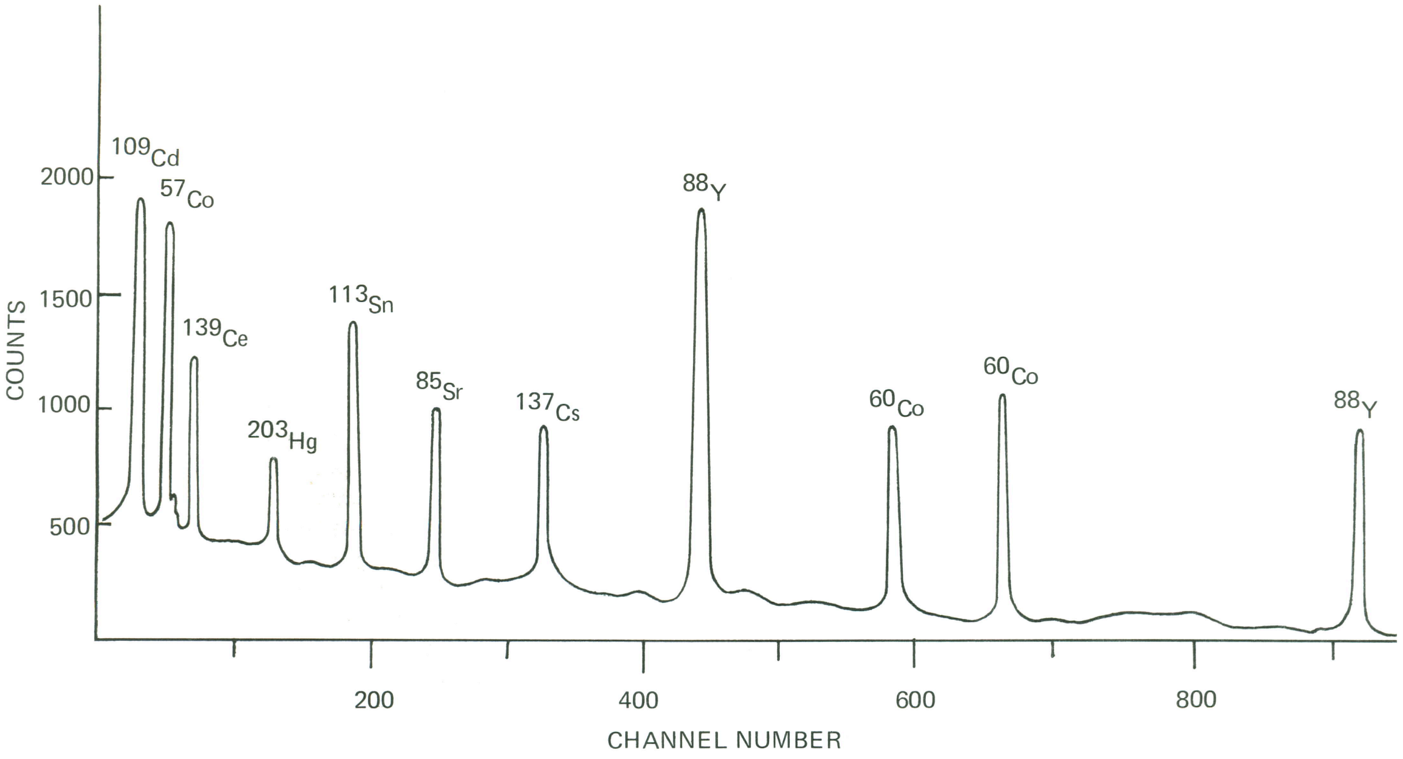
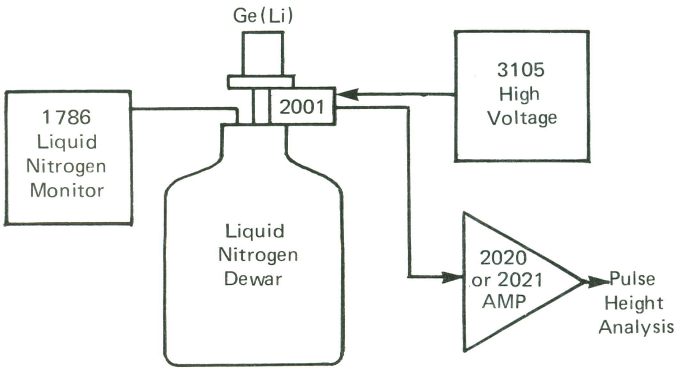


Figure 15. Mixed Radionuclide Spectrum.

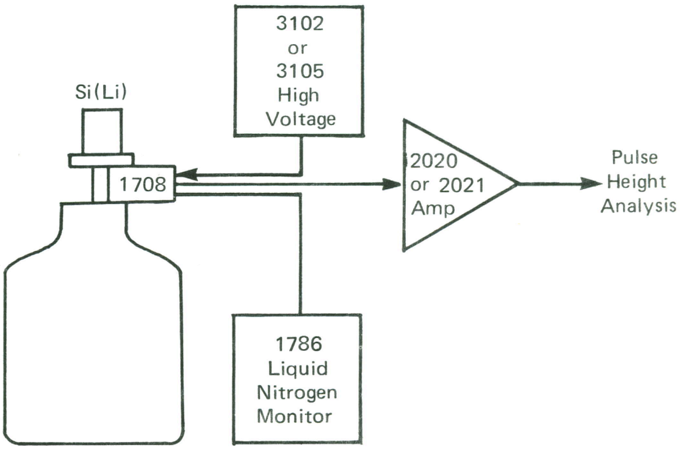
Coaxial Ge(Li) detectors are used for gamma rays in the range of about 80keV to several MeV. The resolution at 122keV is about 1keV, and about 2keV at 1.33MeV. Ge(Li) detectors are priced according to their efficiency and resolution. Efficiencies up to 30% relative to a 3" x 3" NaI crystal at 1.33MeV at a source-to-detector distance of 25 cm are obtainable. A resolution of 2.2keV at 1.33MeV is considered very good, while premium detectors with 1.9keV resolution are available. Figure 15 shows a Ge(Li) spectrum from a mixed nuclide source.

Ge(Li), Si(Li), and high purity Ge detectors are sold complete with cryostat to hold the crystal, liquid nitrogen dewar, and preamplifier. Premium amplifiers have been developed to provide the high gain and low noise needed. These are indicated in Figure 16 for Ge(Li) detectors and in Figure 17 for a Si(Li) detector. Special electronic techniques known as pulsed optical feedback are employed in many planar detectors (Si(Li) and intrinsic). This feedback pulse is very large and must be gated off at the amplifier or handled with a symmetric baseline restorer as in the 2020 or 2021 Amplifier.



Ge(Li)
1786
Liquid
Nitrogen
Monitor
2001
3105
High
Voltage
Liquid
Nitrogen
Dewar
2020
or 2021
AMP
Pulse
Height
Analysis

Figure 16. Ge(Li) Detector Electronics.



Si(Li)
3102
or
3105
High
Voltage
1708
2020
or 2021
Amp
Pulse
Height
Analysis
1786
Liquid
Nitrogen
Monitor

Figure 17. Si(Li) Detector Electronics.

Particle Detection

OVERVIEW

Charged particle detection is much less complex than gamma ray detection because the particles interact directly with the material in the region of ionization, and the path of the particle is more clearly defined. The efficiency for detecting a particle once it has entered the detector is nearly unity, so that efficiencies for standard geometries are generally calculated from solid angle alone. For a small detector at sufficiently large distance from a point source (source-to-detector distance greater than about 3 times detector diameter), the solid angle is A/x^2 steradians, where A is the detector area and x is the source-to-detector distance. At closer distances the formula

$$\text{solid angle} = 2\pi \int_0^{\theta_1} \sin\theta \, d\theta = 2\pi\,(1 - \cos\theta_1)$$

should be used, where θ_1 is the maximum angle subtended by a circular detector. For extended sources at close distances, such as in the Alpha/Beta system (see Systems Section), experimental calibrations should be made.

Many of the types of detectors described above, such as Geiger-Muller counters, proportional counters, and scintillation detectors, are used for charged particle detection. The selection is made upon the basis of resolution (essentially the same as for gamma rays) and range of particle in the gas or scintillator. Ranges of particles in various materials are discussed below. In some cases, such as in the Alpha/Beta system, the particles are not completely stopped within the detector for an energy measurement, but deposit only a portion of their energy. This is related to the relative ionization of the particle and can be used to identify different kinds of particles.

Solid state detectors are also used for charged particle detection, but differ from those used for gamma rays in being very thin and operating at room temperature. They have very good resolution and are used for total energy, or partial energy loss, known as stopping power or dE/dx measurements. These detectors are described in greater detail below. Charged particle characteristics in matter are presented below as a guide to selecting detectors.

Two other detection techniques specific to low-energy electrons are also described. These are electron multipliers and liquid scintillation counters.

CHARGED PARTICLE INTERACTIONS WITH MATTER

The interactons of charged particles with matter are generally expressed in terms of the energy loss per unit path length (also known as stopping power) and the total range of the particle. The range is most important in detector selection, although some applications require the stopping power for particle identification. Electrons must be considered separately from protons and heavier charged particles because they have a less well-defined path length. The energy loss is through collisions with other electrons, so there are angular deviations from the original path direction. In contrast, the much heavier proton or alpha particle isn't deflected from its course by collisions with electrons. For a proton the range and the path length of the particle are essentially the same, while for an electron the path length is much greater than the range.

Electrons lose energy by ionization in atoms, and in radiative collisions. Ionization is the more important process for electrons up to a few MeV, but radiative energy losses increase with energy and become comparable at about 9MeV (in lead). Because of the large path length due to large angle deflections, the range is not difficult to calculate but varies widely from one electron to the next. Empirical values have been determined for various energies and materials. A curve for electron ranges in aluminum is shown in Figure 18, which can be used for all materials since it varies only slightly with stopping material. The range is expressed in mg/cm^2 since this is ρx, density times thickness. This is also the surface density, which for thin foils is a measurement of the weight divided by the area.

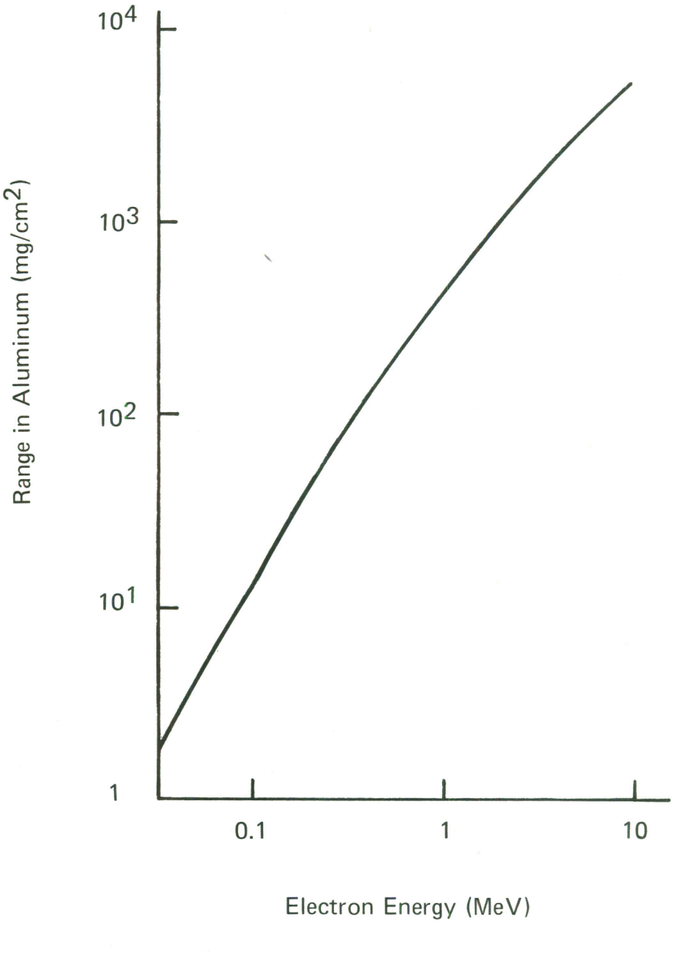


Figure 18. Electron Ranges in Aluminum.

For heavy charged particles in which the path is a straight line while undergoing collisions with electrons, the theoretical energy loss is given by:[4]

$$\frac{dE}{dx} = \frac{-4\pi Z_1 Z_2 e^2 N}{mv^2} \ln \left(\frac{2mv^2}{I} \right)$$

where

m, e = mass, charge of electron
Z_1, Z_2 = atomic numbers of moving particle and stopping material
v = ion velocity
N = number of atoms per unit volume
I = average ionization potential of stopping atom

The logarithmic term varies slowly with energy so that it is approximately correct to write the energy loss as

$$dE/dx = \frac{-\text{Constant}}{E}$$

or as

$$dE/dx = \frac{-Z_1 \text{ Constant}}{E}$$

to identify the charged particle atomic number.

The range is obtained by integrating the stopping power dE/dx over the energy:

$$\text{range} = \int_{E\max}^{o} \frac{dE}{(dE/dx)}$$

Extensive measurements have been made of energy losses of many charged particles in many different materials. Higher Z ions do not behave as a simple Z multiple of protons since they are not completely stripped of electrons. Since the amount of stripping is difficult to calculate, experimental measurements are needed. Experimental data with theoretical extrapolations to provide tables of all ions in various materials at a wide range of energies are available.[5] The dE/dx values are numerically integrated to provide ranges as well.

SURFACE BARRIER DETECTORS

Silicon surface barrier (SSB) detectors have a p-i-n structure in which a depletion region is formed by applying bias, with the resultant electric field collecting the electron-hole pairs produced by an incident charged particle. The resistivity of the silicon must be high enough to allow a large enough depletion region at moderate bias voltages. The gold-silicon detector is commonly available, in which n-type silicon has a Schottky barrier contact as the positive contact. Deposited aluminum is used at the back of the detector for ohmic contact.

At the junction there is a repulsion of majority carriers (electrons in the n-type and holes in p-type) so that a depleted region exists. An applied reverse bias widens this depleted region, which is the sensitive detector volume, and can be extended to the limit of breakdown voltage. Detectors are generally available with depletion depths of 100 to 1000 microns (10^{-6} meters), with the cost approximately proportional to the depletion depth.

Detectors are specified in terms of surface area and alpha or beta particle resolution as well as depletion depth. The resolution depends slightly upon detector size, being best for small area, thin detectors. Alpha resolution of 15 to 35keV and beta resolutions of 7 to 30keV are typical. Areas of 25 to 450mm^2 are available. Detectors are available with fully depleted silicon wafers so that a dE/dx energy loss measurement can be made, with the particle exiting into another detector to measure the remaining energy. These are supplied in a "transmission" mount; the bias connector is on the side of the detector.

A chart of energies of various particles that can be measured with 100, 300, etc. micron depletion depths is shown in Table I. Note that even the thinnest detector is adequate for alpha particles from radioactive sources, but that electrons of only very low energy are completely collected. However, for a surface barrier detector viewing a source of electron lines, such as conversion electron lines, sharp peaks will be observed since some electron path lengths will lie fully in the depleted region. Figure 19 shows ranges of light particles commonly occurring in nuclear reactions.

Depletion Depth (Range)	Maximum Particle Energy (MeV)		
	Electron	Proton	Alpha
100 microns	0.15	7	15
300	0.31	15	55
500	0.45	21	85
700	0.52	27	105
1000	0.73	33	130

Table 1. Particle Ranges and SSB Depletion Depths.

Data Taken from C.F. Williamson, J.P. Boujot and J. Picard, CEA-R-3042 (July 1966)

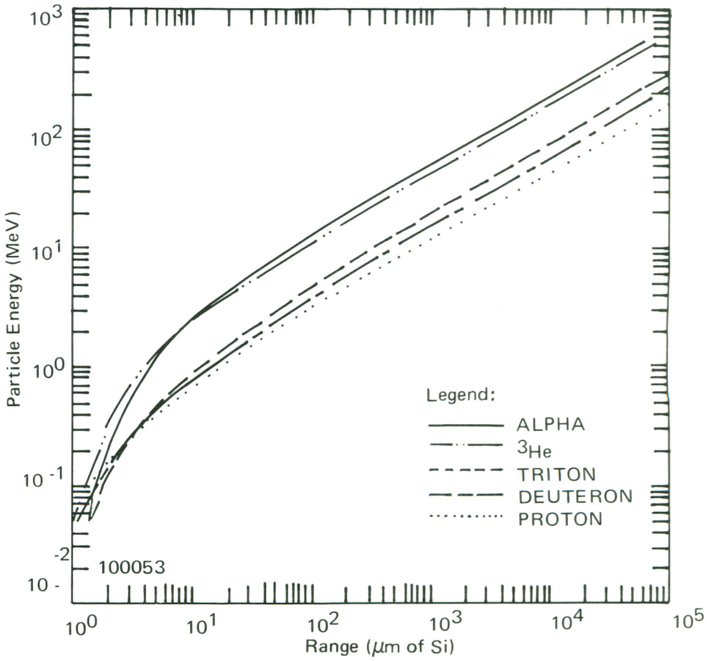


Figure 19. Range-Energy Curves in Silicon.

Since the depletion depth depends upon the applied voltage, the capacitance of the detector is dependent upon the applied voltage. Therefore the output signal from a voltage sensitive preamplifier is also dependent upon the applied voltage. A charge-sensitive preamplifier is used to respond to the charge collected from particle ionization, rather than the voltage of the pulse. Figure 19A shows the electronics used with a surface barrier detector. It's in a vacuum chamber so that energy loss in air is not involved.

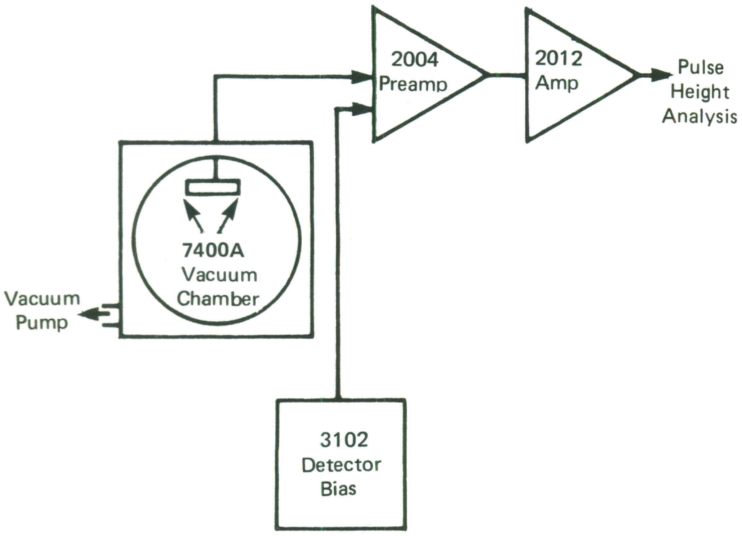


Figure 19A. SSB Electronics.

ELECTRON MULTIPLIERS

In a photomultiplier tube each dynode multiplies the electron current reaching it. Such a multiplication can be used directly on very weak electron pulses rather than an electron from the photocathode to achieve pulse amplification. Electron multipliers are commercially available in many configurations, ranging from continuous dynode tubular structures to parallel plate units, and even more special devices. The scintillation preamplifier can be used for electron multipliers. Electron multipliers are normally used in a vacuum in such applications as the detector in mass spectrometers, Auger spectrometers, and vacuum ultraviolet spectrometers.

LIQUID SCINTILLATORS

Two very important beta-emitting isotopes, tritium and C-14, have very low energy beta rays. They are at 19 and 156keV, which are too low to detect reliably with solid scintillators. Further, many of the samples are conveniently processed in liquid form. The liquid scintillation technique involves mixing a liquid scintillator with the sample, and then observing the light pulses with one or more photomultiplier tubes. The sample must of course be transparent.

The use of "internal" liquid scintillators should be distinguished from liquid scintillators used for neutron detection, as discussed below.

NEUTRON DETECTION

Neutrons cannot be detected since they have no charge to produce ionization; therefore secondary processes are required. There are three common procedures:

a. Detection of nuclear reaction products following neutron capture.
b. Detection of recoil protons following elastic scattering.
c. Detection of beta or gamma radiation of long-lived isotopes following neutron capture.

The nuclear reactions can be (n, α), (n, p), or (n, fission product). The reaction

$$n + {}^{10}_{5}B \rightarrow \alpha + {}^{7}_{3}Li$$

is commonly used to detect thermal neutrons by using a gas detector filled with BF_3. The alpha particle is emitted with 1.8MeV of energy and produces the ionization. For neutron flux measurements of high numbers of neutrons the detector is operated as an ionization chamber, while for low count rates the Geiger region is appropriate. Helium-3 is also used as a fill gas. The reaction used in this case is

$$n + {}^{3}He \rightarrow p + {}^{3}H$$

The ${}^{3}H$ and proton are both detected. Helium-3 counters are usually operated at higher pressures than BF_3 counters and can therefore have higher efficiencies. A typical configuration is shown in Figure 20.

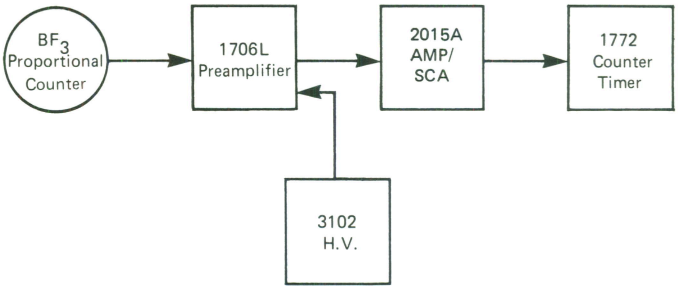


Figure 20. BF_3 Counter Electronics.

For neutrons of higher than thermal energies the ${}^{10}B$ and ${}^{3}He$ capture cross sections are very small and it is necessary to thermalize or slow down the neutrons. Hydrogen-rich materials such as water or plastic are commonly used to thermalize neutrons. Fission detectors are used for thermal energies and for higher energies by selecting the fissioning material. U-235 is used for thermal neutrons and U-238 or Np-237 for higher energy (fast) neutrons. The fission fragments following capture are very energetic, and are easily detected in an ionization chamber.

Fast neutrons are measured also by detecting the recoil protons. Neutron spectra can be obtained observing the protons in a surface barrier detector. For a specific neutron energy there will be a continuum of proton energies up to the neutron energy, with a sharp cut-off. Proton spectra can be unfolded to derive the neutron spectra. Recoil protons can also be detected in gas detectors in which hydrogen or a hydrogen-rich gas (such as methane) is present.

The third technique of neutron detection is through activation of a long-lived isotope. For example, activation of Indium - 115 to Indium - 116 which decays by beta emission with a 54 minute half-life can be used to measure neutron fluxes since the capture cross section is known.

LIQUID SCINTILLATORS AND PULSE SHAPE DISCRIMINATION

Since neutrons are detected through nuclear reactions rather than directly by electronic processes, neutron detection is very inefficient because of the small size of the nucleus. Large volume neutron detectors can be made for increased efficiency by using liquid scintillators. However, the gamma ray background can become appreciable, even though the scintillator is low-Z material. Pulse shape discrimination can be used to distinguish between gamma rays and neutrons with a circuit that responds differently to the fast rise time of neutron pulses than for the slower rise time of pulses from gamma rays.

Basic Counting Systems

PULSE ELECTRONICS

The nuclear electronics industry has standardized the power supply voltages, physical dimensions, and pulse signal definitions for the basic detector electronics. This standardization of nuclear instrumentation modules (NIM) provides the user with interchangeability and flexibility as his experimental or application needs change or grow. Canberra Industries is a leading supplier of NIM, which is presented and described in Section 4 of this catalog. Basic electronic functions and configurations are discussed below, and greater detail can be found in the Introductons to the subsections in the NIM part of the catalog.

Preamplifier and Amplifier

Most detectors can be represented as a capacitor into which a charge is deposited, as shown in Figure 21. The detector bias provides an electric field to collect the charge. During the charge collection a small current flows, and the voltage drop across the bias resistor is the pulse voltage.

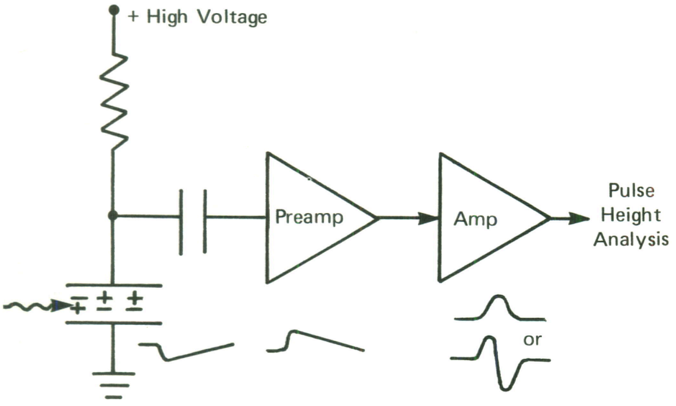


Figure 21. Basic Detector and Amplification.

The preamplifier is isolated from the high voltage by another capacitor. The rise time of the pulse is related to the collection time of the charge, while the decay time of the pulse is the RC time constant characteristic of the preamplifier itself. Rise times range from a few nanoseconds up to a few microseconds while decay times are usually set at about 50 microseconds.

The charge-sensitive, rather than voltage-sensitive, preamplifier is commonly used for most solid state detectors. An output voltage pulse is produced that is proportional to the input charge. The output voltage is essentially independent of detector capacitance; this is especially important for silicon surface barriers since the detector capacitance depends strongly upon the bias voltage. However, the noise level is affected by the capacitance.

The preamplifier should be located at the detector to reduce capacitance of the leads, which can degrade the rise time as well as lowering the effective signal size. The preamplifier also serves to provide a match between the high impedance of the detector and the low impedance of coaxial cables to the amplifier, which may be located at great distances from the preamplifier.

The amplifier serves to shape the pulse as well as further amplify it. The long decay time of the preamplifier pulse may not be returned to zero voltage before another pulse occurs, so it is important to shorten it and only preserve the detector information in the pulse rise time. The RC clipping technique can be used, in which the pulse is differentiated to remove the slowly varying decay time, and then integrated somewhat to reduce the noise. The unipolar pulse that results is much shorter. The actual circuitry used is an active filter for selected frequencies. A near-Gaussian pulse shape is produced, yielding optimum signal-to-noise characteristics and count rate performance.

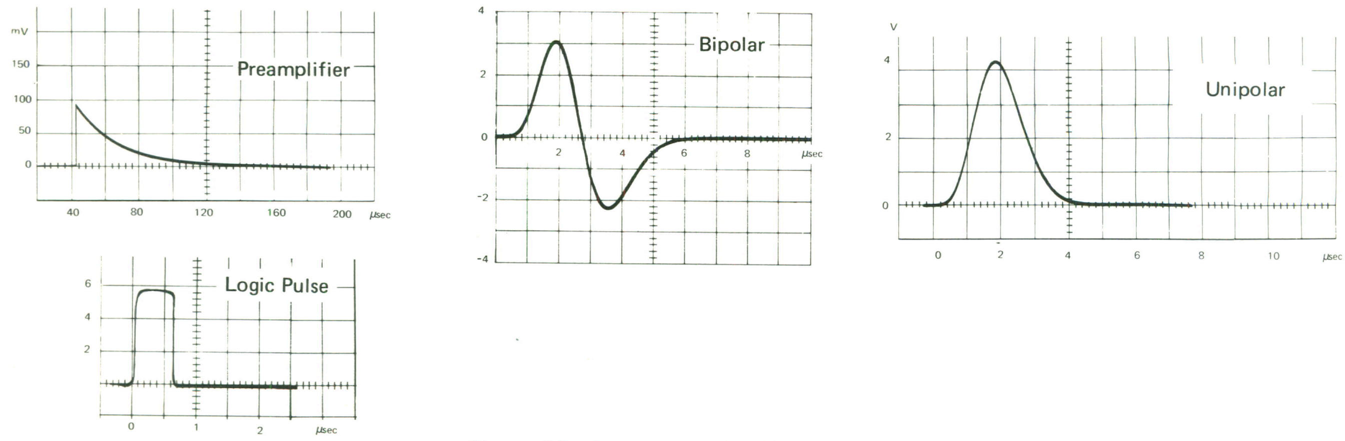


Figure 22. Standard Pulse Waveforms.

A second differentiation produces a bipolar pulse. This bipolar pulse has the advantage of nearly equal amounts of positive and negative area so that the net voltage is zero. When a bipolar pulse passes from one stage of a circuit to another through a capacitor, no charge is left on the capacitor between pulses. With a unipolar pulse the charge must leak off through associated resistance or be reset to zero with a baseline restorer.

Typical preamplifier and amplifier pulses are shown in Figure 22. The dashed line in the unipolar pulse indicates undershoot which can be removed to return to zero baseline voltage more quickly by means of a pole/zero adjustment. Further discussion on preamplifier and amplifier characteristics accompanies those sections of this catalog.

The bipolar pulse has the further advantage over unipolar in that the zero crossing point is nearly independent of time (relative to the start of the pulse) for a wide range of amplitudes. This is very useful in timing applications, as discussed below. However, the unipolar pulse has lower noise, and constant fraction discriminators have been developed for timing with unipolar pulses.

Pulse Height Analysis — SCA and MCA

Pulse height analysis may consist of a simple discriminator that can be set above noise level and which produces a standard logic pulse for counting in a scaler or pulse counter. However, most data consists of a range of pulse heights of which only a small portion is of interest. One can employ either of the following:

1. Single Channel Analyzer and Scaler
2. Multichannel Analyzer

The single channel analyzer (SCA) has a lower and an upper level discriminator, and produces an output logic pulse when the input pulse lies between the discriminator levels. With this device all voltage pulses in a specific range can be selected and counted. An additional SCA and scaler can be added for a second voltage range, and so on, but the expense and complexity usually make more than two prohibitive.

If a full voltage spectrum is desired, the SCA discriminators can be set to a narrow range and then stepped through higher and higher voltages, determining the counts at each step. This can also be accomplished automatically with an SCA Sweep, as shown in Figure 23. The Model 2030 has an external baseline reference mode so that its lower level discriminator can be controlled by the SCA sweep. A ratemeter and strip chart recorder can then be used to record a full voltage spectrum. However, the full data collection can take a long time with a single channel analyzer. All pulses outside the SCA window are lost, so that the smaller the window for better resolution, the longer the time required to get adequate counts. The Model 2015 Amp/SCA and Model 2035A Timing SCA also have external baseline reference inputs.

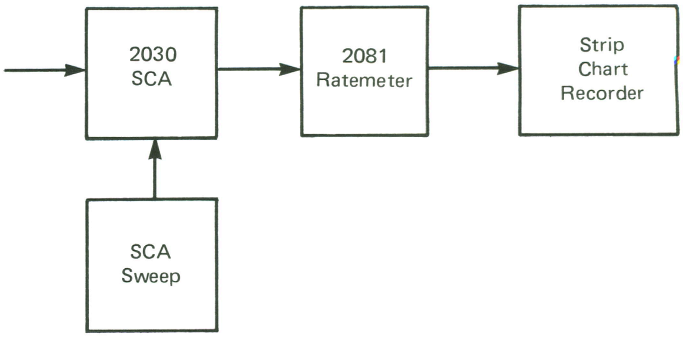


Figure 23. Ratemeter and SCA Sweep Use.

The multichannel analyzer (MCA) provides a convenient way of collecting an entire spectrum at once. The MCA consists basically of an analog-to-digital converter (ADC), a memory, and a display oscilloscope. MCAs can become very extensive (see MCA section) with output devices, built-in amplifiers and preamplifiers, and data analysis functions. The MCA collects pulses in all voltage ranges at once, providing a major improvement over SCA spectrum analysis.

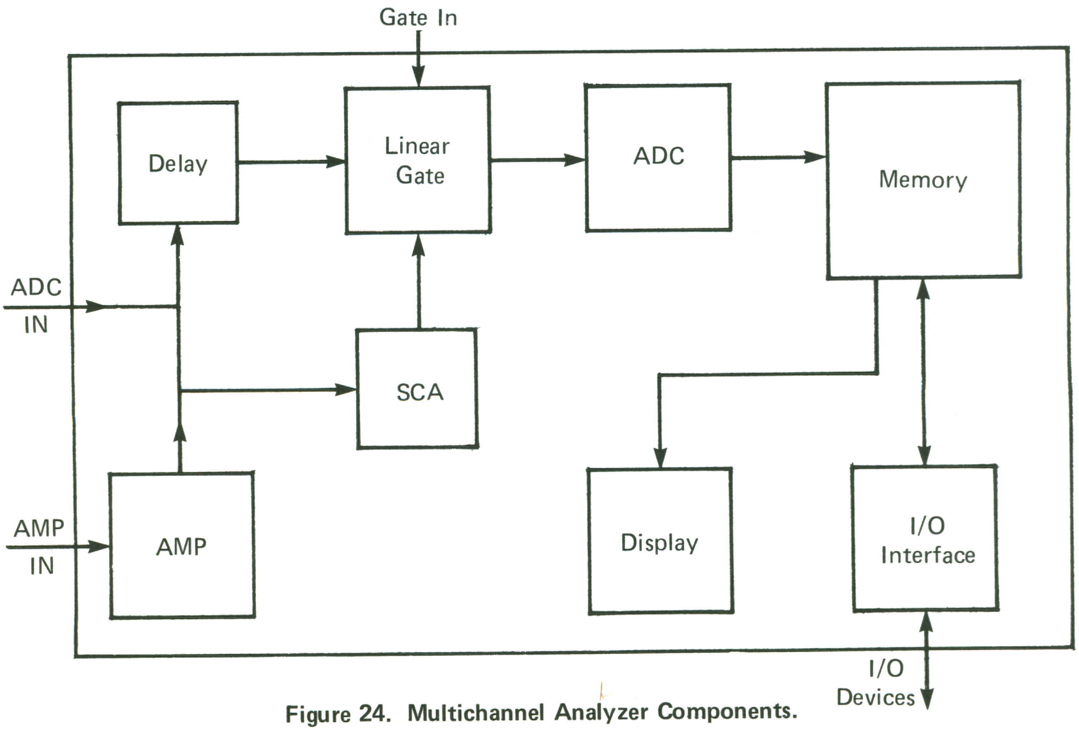


Figure 24. Multichannel Analyzer Components.

Figure 24 shows a block diagram of a basic MCA. An input pulse is checked to see if it is within the selected SCA range, and then passed to the ADC. The ADC converts the pulse to a number proportional to the pulse voltage. This number is taken to be the address of a memory location, and one count is added to the contents of that memory location. After collecting data for some period of time, the memory contains a list of numbers corresponding to the number of pulses at each discrete voltage. The display reads the memory many times per second, producing a point plot of memory contents vs memory location, which is equivalent to number of pulses vs voltage.

Scalers and Ratemeters

Scalers and ratemeters are used to count pulses, either on an individual basis in a scaler, or as averages in the ratemeter. Scalers and ratemeters are built with very high count rate capabilities so that dead times are low. Scalers usually have an LED display and are built with many of these additional features:

- Discriminator
- Printout Capability
- Internal Timer

Ratemeters have a meter indicating count rate, and are available with:

- Linear or Log Scale
- Selectable Time Constants
- Recorder Output
- Alarm Level and Output

Additional information is provided in the introductions to the sections on digital NIM and ratemeters.

Miscellaneous Units

Various pulse processing functions have been incorporated into NIM units, such as linear gates, pulse generators, pulse stabilizers and the like. Many of these are described in the following sections and in the specific NIM section introduction.

SCALER SYSTEMS

As related above, pulse height analysis can consist of a simple single channel analyzer and scaler, or a multichannel analyzer. Generally, the low resolution, high efficiency detectors are used in applications where only a single peak occurs, such as with X-rays or low-energy gamma rays in proportional counters or NaI detectors. Two such systems are shown in Figures 25 and 26. A 2015A Amplifier/SCA combined NIM unit is employed, as well as the 1772 and 1775 units which can provide preset time or preset count operation. The 1775 Counter has printout capability as well so that a 2089 Scanner/Printer can be connected to it to provide a printed record of the scaler contents when preset time or counts are reached.

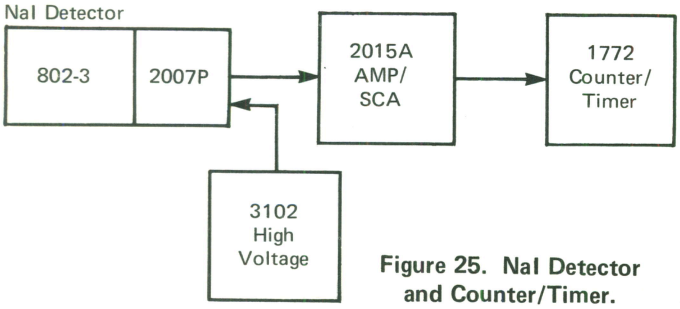


Figure 25. NaI Detector and Counter/Timer.

Both the Model 1772 and Model 1775 counters have discriminators on the positive input pulse, so that in applications where only a lower level discriminator is required the SCA unit is not needed. The Model 1775 may be preset on time to display counts (counts can be printed) or preset on counts to display time (time can be printed), while the Model 1772 is preset on time only.

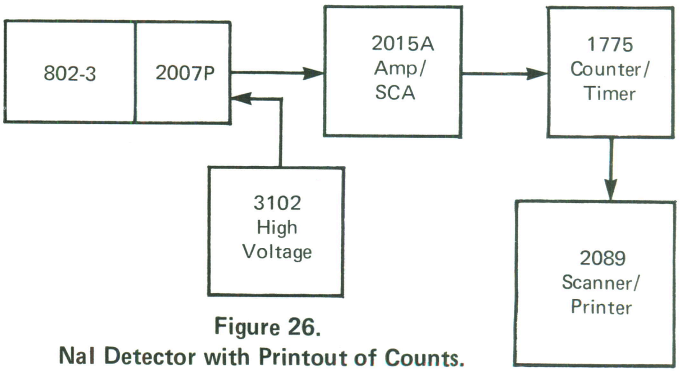


Figure 26. NaI Detector with Printout of Counts.

Multiple scaler systems with readout or output to computer can also be set up. Several such systems are shown below. Figure 27 uses a 1776 Dual Counter/Timer to display time and counts simultaneously (the 1775 displays counts *or* time) and a 1773 Scaler or a slave unit for the second detector.

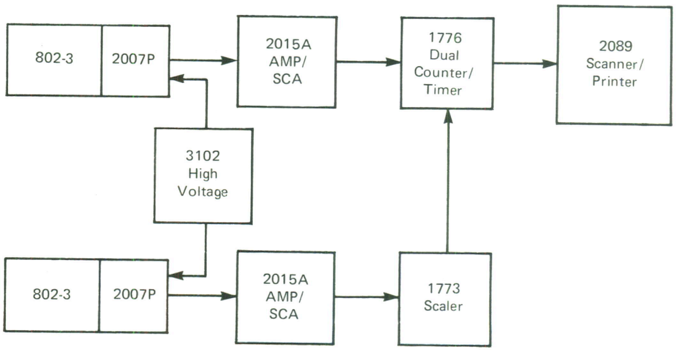


Figure 27. Dual Detector and Printout System.

One advantage of the 1776 over the 1775 is that both time and counts can be printed. The 1776 has the additional capability of preset on either channel A or B. If the preset time is not required to be printed, another possible configuration besides the 1775 and 1773 is a 1770 Timer/Scaler and 1774 Dual Scaler, as shown in Figure 28. The 1770 is an inexpensive unit without display or printout capability that can be used as a system master.

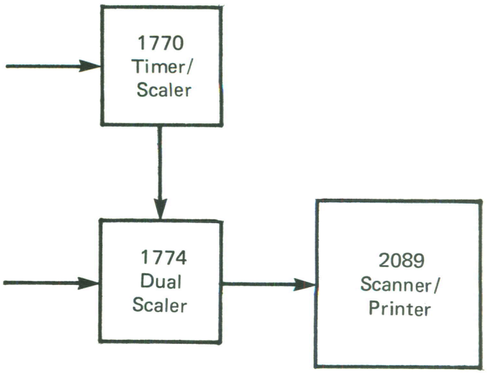


Figure 28. Dual Scalers with Printout.

The preset time and two counting channels may be all printed out from a single unit by using the Model 1790C Universal Counter/Timer, as shown in Figure 29. In this case the SCA and the upper level discriminator from a scaler are both recorded, as well as the preset time. The display register can be selected to indicate time or either counting channel.

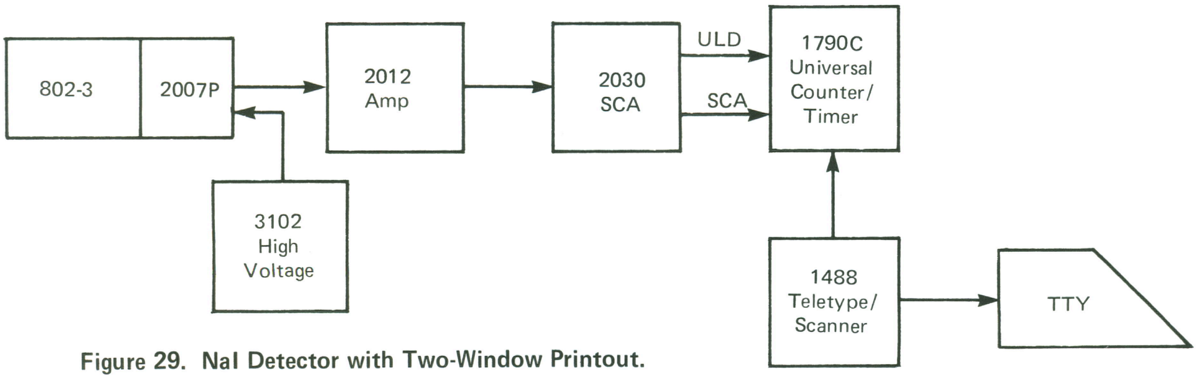

802-3
2007P
2012 Amp
2030 SCA
ULD
SCA
1790C Universal Counter/ Timer
3102 High Voltage
1488 Teletype/ Scanner
TTY

Figure 29. NaI Detector with Two-Window Printout.

The 1790C can also be used as the master unit and the readout for an array of blind scalers. A blind scaler system with readout represents a substantial cost saving over scalers with individual displays if there are a large number of inputs. Each 1476A Blind Scaler can be selected for visual readout on the 1790C. Figure 30 shows a possible system with 1476A Blind Scalers and a 1790C for system control and readout to a computer system. If no visual display is required, the 1790C can be replaced by the 1490C Blind Timer as system master. Many additional scaler features are described in detail in the section entitled Digital NIM.

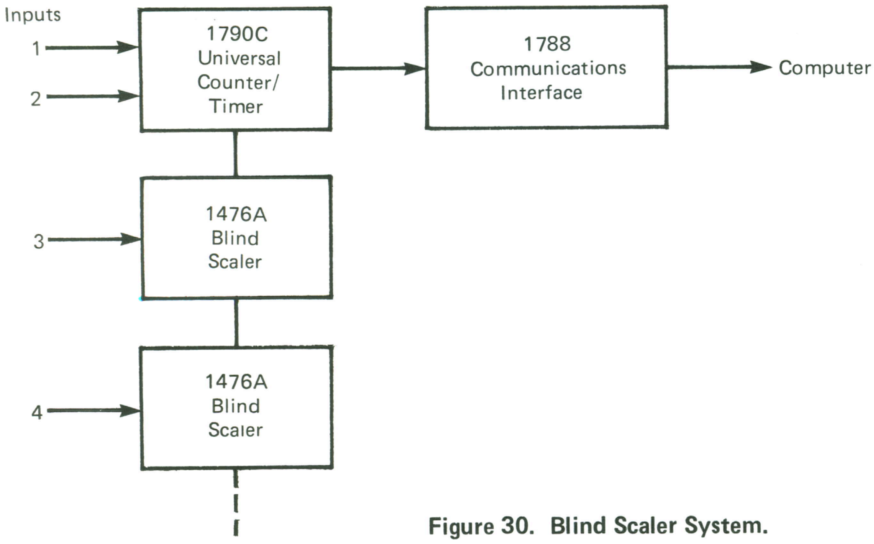

Inputs
1
2
3
4
1790C Universal Counter/ Timer
1788 Communications Interface
Computer
1476A Blind Scaler
1476A Blind Scaler

Figure 30. Blind Scaler System.

NaI DETECTORS AND MULTICHANNEL ANALYZERS

Multichannel analyzers can include much of the electronics necessary to operate a detector. A common configuration is the NaI detector and MCA, with preamplifier, amplifier, and high voltage supply internal to the MCA. Figure 32 shows the MCA and components for an NaI detector and Series 30 MCA. This combination provides a convenient low-cost analysis system that can be made portable by use of a battery and AC inverter.

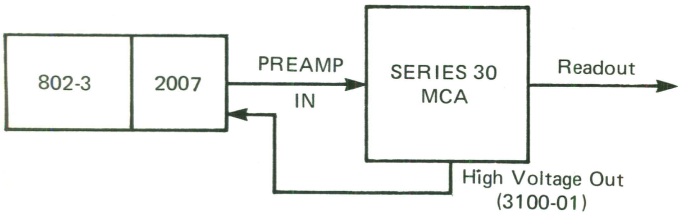

802-3
2007
PREAMP
IN
SERIES 30
MCA
Readout
High Voltage Out
(3100-01)

Figure 32. MCA with Internal Preamplifier and Amplifier.

SURFACE BARRIER DETECTORS AND MULTICHANNEL ANALYZER

Alpha spectroscopy measurements of low-level samples require long counting times. A large area silicon surface barrier detector with a multichannel analyzer provides a high resolution, low background counting system. Figure 33 shows a multiple detector system that provides four detectors with vacuum chamber, preamplifier, amplifier and bias supply, with each detector signal routed into a different quadrant of the MCA memory. This provides maximum utilization of the MCA for low count rates.

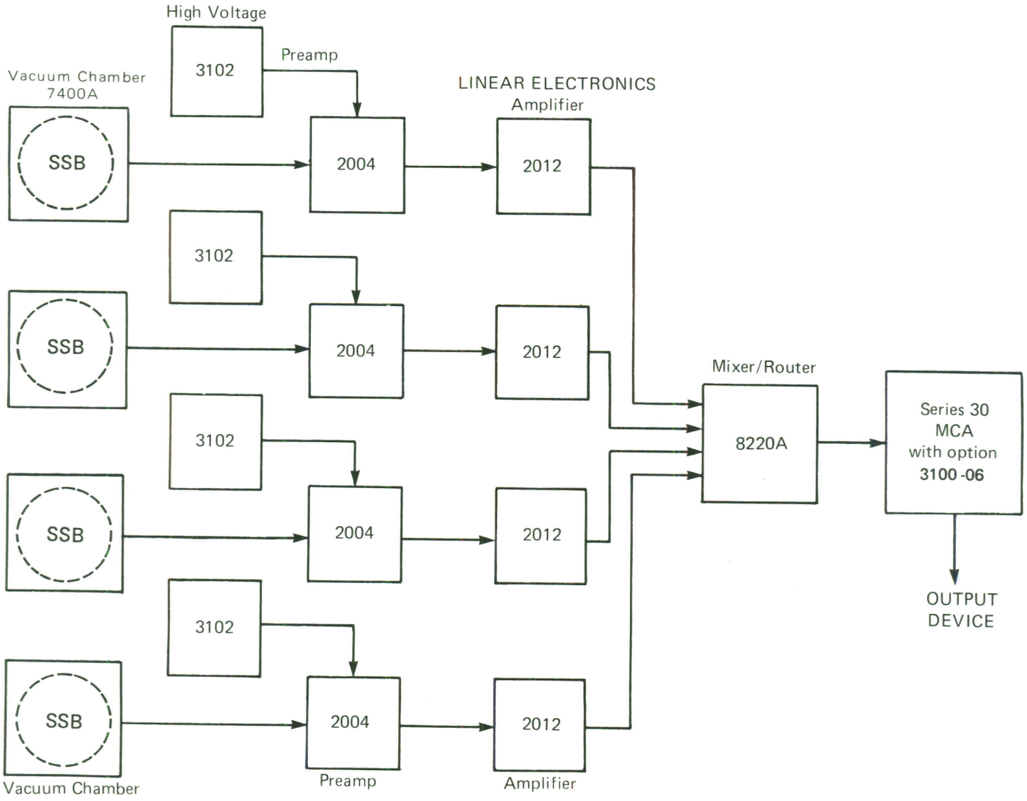

High Voltage
3102
Preamp
Vacuum Chamber
7400A
LINEAR ELECTRONICS
Amplifier
SSB
2004
2012
3102
SSB
2004
2012
Mixer/Router
8220A
Series 30
MCA
with option
3100-06
3102
SSB
2004
2012
OUTPUT
DEVICE
3102
SSB
2004
2012
Vacuum Chamber
Preamp
Amplifier

Figure 33. Four-Input Alpha Spectroscopy System.

The long counting times require high stability electronics. Canberra's electronics provide a system with good temperature stability and drift-free performance to assure successful measurements.

Not shown in the diagram are vacuum pumps, vacuum hose and filters, which are listed on the NIM Accessories Price List.

Ge(Li) DETECTOR AND MULTICHANNEL ANALYZER

The high resolution of a Ge(Li) detector virtually requires the multichannel analyzer for spectrum analysis. A standard amplifier and Ge(Li) system may consist of the high voltage power supply, preamplifier (which is usually sold as part of the detector), amplifier and MCA, as shown in Figure 34, or as a system that uses an amplifier internal to the MCA.

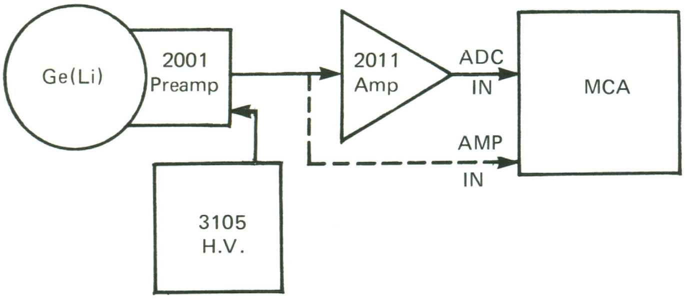

Ge(Li)
2001
Preamp
2011
Amp
ADC
IN
AMP
IN
MCA
3105
H.V.

Figure 34. Ge(Li) Detector and MCA.

For high count rate Ge(Li) detectors it is common to use an additional circuit to reject pileup pulses that can distort the spectrum. The Model 1468A Live Time Corrector/Pileup Rejector inspects both the leading edge and the trailing edge of the pulse and can discriminate between two events separated by less than 0.5 microseconds. Since these pileup pulses are rejected, the ADC live time must be corrected to indicate a system live time. The Series 40 MCA provides signal paths for live time correction of the ADC to indicate system live time, as is shown in Figure 35.

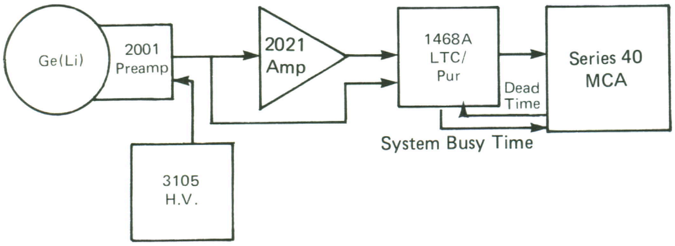

Ge(Li)
2001
Preamp
2021
Amp
1468A
LTC/
Pur
Dead
Time
Series 40
MCA
System Busy Time
3105
H.V.

Figure 35. Ge(Li) Detector with Pileup Rejection and MCA.

The Series 80 MCA has an internal amplifier/pileup rejector/live time corrector equivalent to the 1468A, as shown in Figure 36. A Model 1786 Liquid Nitrogen Monitor and Alarm is also indicated to provide continuous monitoring of the amount of liquid nitrogen present in the storage dewar and to give a visual and audible indication when the level is low.

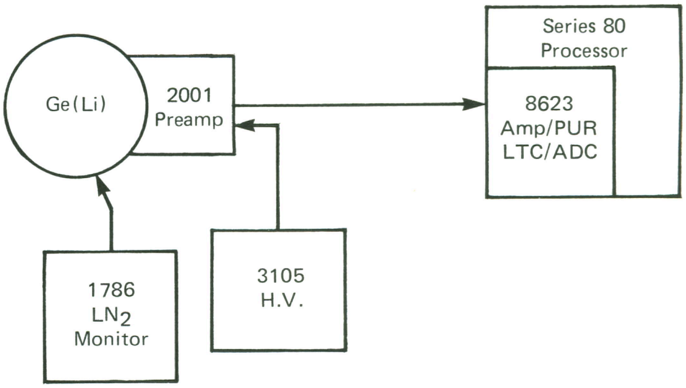

Series 80
Processor
Ge(Li)
2001
Preamp
8623
Amp/PUR
LTC/ADC
1786
LN2
Monitor
3105
H.V.

Figure 36. Ge(Li) Detector and MCA with Internal Pileup Rejection.

PLANAR Ge/Si(Li) DETECTOR AND MULTICHANNEL ANALYZER

The Planar Ge and the Si(Li) detector require special electronics in order to provide the long time constants required in the amplifier to achieve good resolution and to properly remove the pulsed optical feedback signals. As noted earlier, only the 2020 and 2021 amplifiers are suitable. In high count rate applications, the long time constants contribute to Pulse Pileup. The 2020 contains a built-in Live Time Corrector/Pileup Rejector to prevent these inaccuracies. Such a system is indicated in Figure 37, and includes a Model 1786 Liquid Nitrogen Monitor and Alarm.

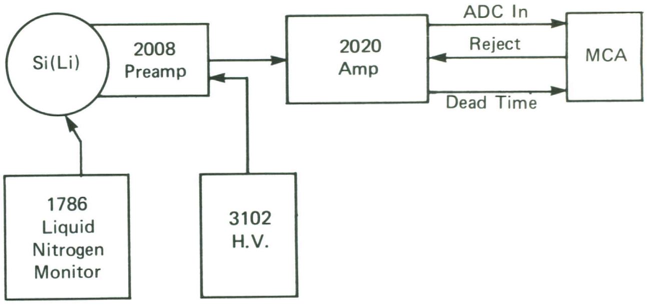

ADC In
Reject
Dead Time
Si(Li)
2008
Preamp
2020
Amp
MCA
1786
Liquid
Nitrogen
Monitor
3102
H.V.

Figure 37. Si(Li) Detector & MCA System.

X-RAY PANEL

Many X-ray applications, such as Bragg scanning, require high count rate capability with an absolute minimum of count losses. Careful attention has been given to the Canberra X-ray panel to assure count loss of less than 1% at high count rates up to 50,000 counts per second. The gain shift and system drift associated with high count rates and temperature changes are accounted for with Canberra's unique spectrum stabilizer. The Model 2050 Spectrum Stabilizer, used in conjunction with the Model 1718 X-Ray Amplifier/Pulse Height Analyzer, as shown in Figure 38, operates on the amplified pulses corresponding to a selected peak.

Two detectors are indicated, a gas proportional counter with high count rate 1706 Preamplifier, and the integral NaI unit consisting of a thin Be window on a thin NaI(Tl) crystal, and photomultiplier tube. The 1718 Amplifier/PHA provides high count rate capability with very short pulses for less than 200 nanosecond dead time. It is designed to accept pulses directly from the photomultiplier tube without a preamplifier. Gain changes of - 50% to +100% are corrected by the spectrum stabilizer. The ratemeter provides a convenient fast way to select the peak settings on the PHA (SCA) part of the 1718 Amp/PHS module, which can be recorded on a strip chart recorder. The 1776 Dual Counter/Timer displays both counts and time and can be output to teletype or printer or paper tape or EIA device as indicated. Of course, other scaler or timer units can be used instead. Figure 39 shows the system layout.

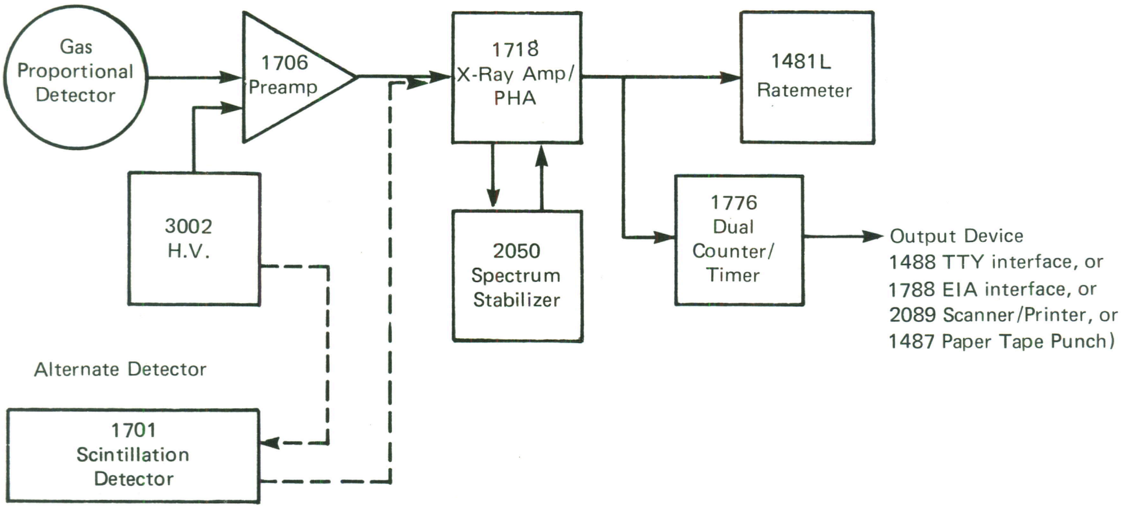

Gas Proportional Detector
1706 Preamp
1718 X-Ray Amp/ PHA
1481L Ratemeter
3002 H.V.
2050 Spectrum Stabilizer
1776 Dual Counter/ Timer
Output Device
1488 TTY interface, or
1788 EIA interface, or
2089 Scanner/Printer, or
1487 Paper Tape Punch)
Alternate Detector
1701 Scintillation Detector

Figure 38. Typical X-Ray Panel

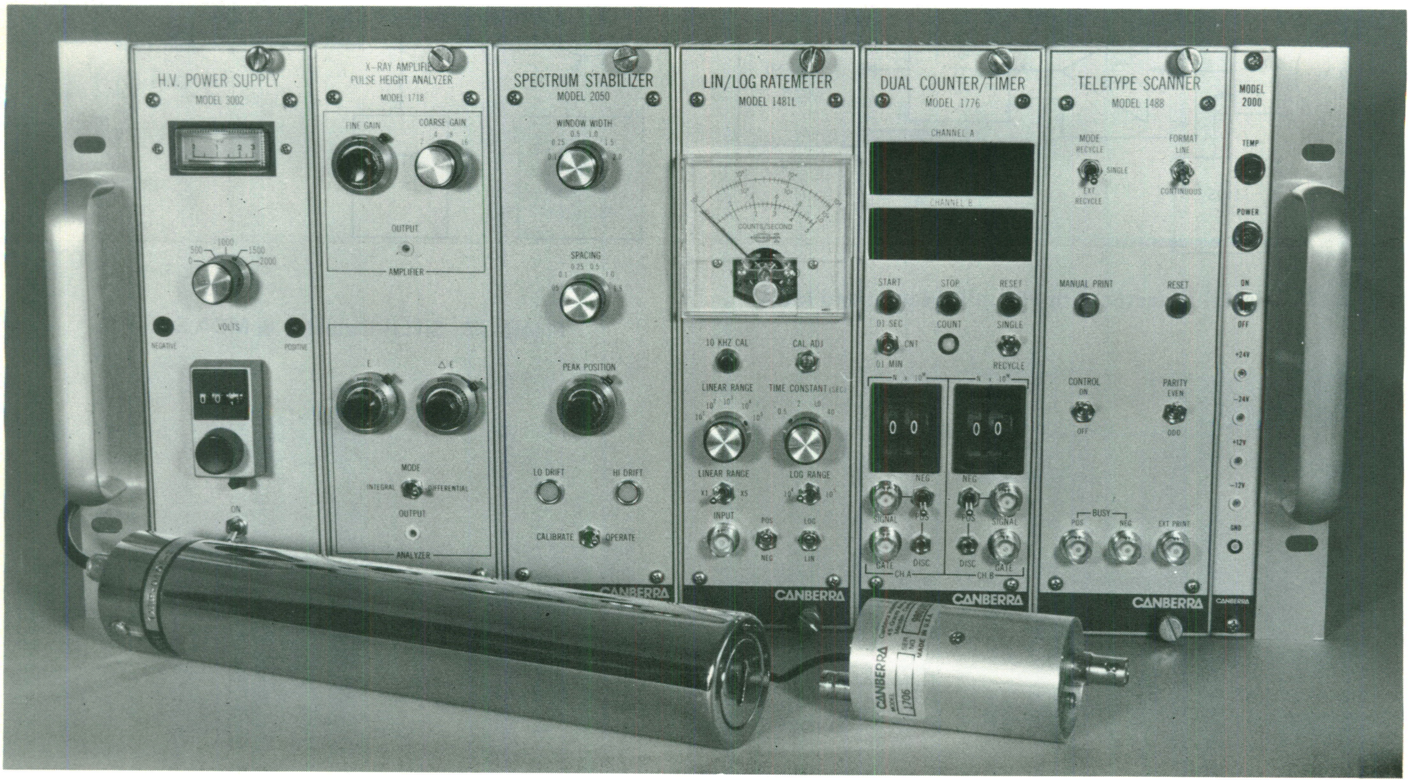

H.V. POWER SUPPLY MODEL 3002
X-RAY AMPLIFIER PULSE HEIGHT ANALYZER MODEL 1718
SPECTRUM STABILIZER MODEL 2050
LIN/LOG RATEMETER MODEL 1481L
DUAL COUNTER/TIMER MODEL 1776
TELETYPE SCANNER MODEL 1488
MODEL 2000
CANBERRA

Figure 39. X-Ray Panel, showing 1702 Detector and 1706 Preamp

LOW LEVEL GAMMA RAY COUNTING

Large volume Ge(Li) detectors have become dominant over other detector types for low level gamma ray spectroscopy because of their inherently good resolution. It is only in the analysis of single radioisotopes that NaI(Tl) detectors can compare in sensitivity with modern Ge(Li) detectors. This discussion, therefore, will be limited to the application of Ge(Li) detectors to low level counting.

The sensitivity of a Ge(Li) spectrometer system depends on several factors, including detector efficiency, detector resolution, background radiation, sample constituency, sample geometry and counting time. A discussion of the role these factors play is given next:

1. EFFICIENCY: Generally, the sensitivity of a Ge(Li) system will be in direct proportion to the detector efficiency. Other factors being equal, this applies even when the measure of efficiency is the simplistic ubiquitous "Relative Efficiency". There are potential shortcomings in this specification of Ge(Li) detector performance, however, as explained below.

   Although Ge(Li) detectors are almost universally specified for efficiency relative to a 3" NaI(Tl) at 25cm detector-to-source distance at 1.33MeV, this may represent little to the customer who is counting weak samples with gamma energies of 100-800keV. It is not unheard of, nor surprising, that a 10% Ge(Li) may outperform a 15% Ge(Li) under certain conditions.

   For sample counting at energies of 1MeV or so and below, the following subtle considerations to the detector design are important to system performance:

   a. Detector geometry should be oversquare, i.e. diameter should exceed length. This assures that the efficiency at medium and low energies will be high relative to the efficiency at 1.33MeV, where it is bought and paid for.

   b. Detector to End Cap distance should be minimal — five millimeters or less. The inverse square law is real and will affect sensitivity.

   c. Detector should be of closed end coaxial geometry, to assure that there will be no dead "P-core" facing the sample.

2. RESOLUTION: Generally, the resolution of Ge(Li) detectors is sufficiently good to avoid the problem of peak convolution, i.e. the peaks are separate and distinct. The sensitivity of the system, then, improves as the resolution improves, in that the spectral line width is less and therefore fewer background counts are obtained in doing peak integrals.

   Since the sensitivity is related to background to the - 1/2 power, i.e.

   $$\text{Sensitivity} \propto \frac{1}{\sqrt{\text{Bkg}}}$$

   improvements in resolution will not improve sensitivity as dramatically as increased efficiency.

3. BACKGROUND RADIATION AND SAMPLE CONSTITUENCY: Interfering background in gamma spectra originates either from within the sample being counted (Compton-produced) or from the environment. If the sample being analyzed has a high content of high-energy gamma emitting radioisotopes, the Compton-produced background will easily outweigh the environmental background. For extremely weak samples, the environmental background becomes more significant. Obviously, massive shielding will do little to improve system sensitivity for low energy gamma rays in the presence of relatively intense higher energy radiation. Compton-suppression can, however, be very effective in reducing this background.

4. SAMPLE GEOMETRY: One often overlooked aspect of Ge(Li) detector sensitivity is the sample geometry. For a given sample size (and the sample size should be as large as practicable for maximum sensitivity), the sample should be distributed so as to minimize the distance between the sample volume and the detector itself.

   This, of course, rules out "test tube" samples, or large area flat samples for that matter. It rules in the use of re-entrant or Marinelli breaker type sample containers which distribute part of the sample around the circumference of the detector.

Ge(Li) DETECTOR WITH INERT SHIELD

There are many shield designs, and because of the difficulty in determining the background contribution of the materials used in a given shield, it is difficult to assign performance levels to various types of shields. Some criteria for shield designs have evolved over the years, however, as given next:

1. The size and weight should be kept to a minimum, i.e. the shield should not be designed to contain unnecessary system components like the dewar. It will only contribute to background if it is within the walls of the shield, and it takes up an extraordinary amount of space.

2. The detector should be readily installed and removed from the shield.

   Pity the person who has to move lead brick (at 26 lbs. each) to disengage a Ge(Li). The most famous last words in the business are "I don't intend to move it once it's installed". A Ge(Li) and shield system should have a liquid nitrogen transfer system to avoid removing the detector for the weekly filling.

3. Sample entry should be convenient to the operator.

   Somebody is going to have to change samples if the system is used and it is no fun to get down on one's knees "n" times a day to do so.

4. The shield should accommodate a variety of sample sizes and configurations.

   The Ge(Li) detector should be located in the center of the shield so as to minimize scatter from the walls. In this position, the shield should accommodate the largest sample that is anticipated. Also, sample placement should be accurately repeatable and easily verified by the operator.

One shield design that has all these features and is moderately priced is the Canberra unit illustrated in Figure 40 & 40A.

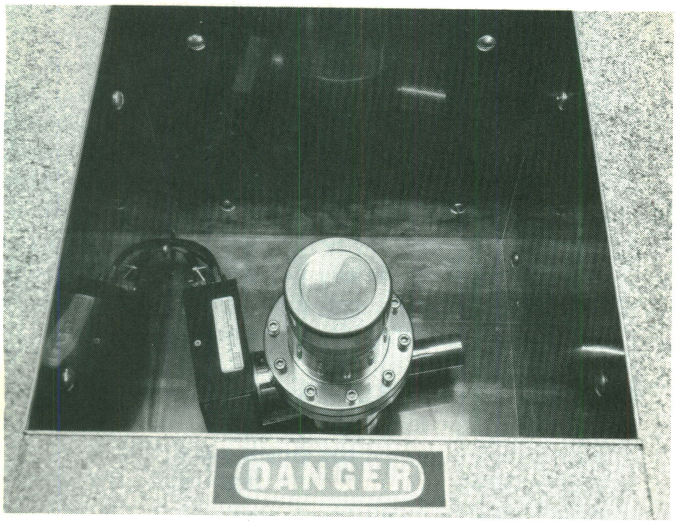


Figure 40. Detector located in center of chamber without requirement for extended end-cap.

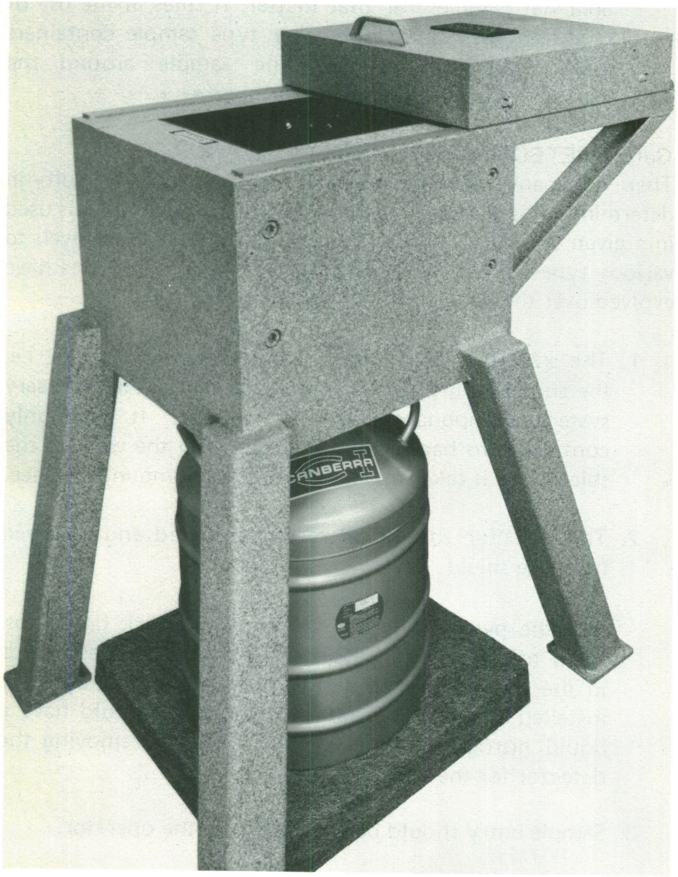


Figure 40A.

- **A. Full Access to counting chamber provided by roll-top cover.**
- **B. Sample entry is at convenient working level.**
- **C. Floor of Cave has 1-5/8" diameter hole for dipstick portion of cryostat.**
- **D. Dewar located below counting chamber.**

The performance of the shield using a C.I. Ge(Li) detector is given below.

Shield Specs:	Inside Dimensions	12" x 12" x 16"
	Wall thickness	4"
	Material	Old Steel (Pre WWII)
Ge(Li) Specs:	Rel. Efficiency	12%
	Resolution	1.95keV FWHM at 1.33MeV 0.90keV FWHM at 122keV

Background Count: 2.25 counts/sec. in the 50keV - 2.7MeV range

Sensitivity: assuming 50% error, a counting time of 50,000 seconds, and a detector to point source distance of 1 cm, the following sensitivities were determined for the single radioisotopes listed.

RADIONUCLIDE	ENERGY	SENSITIVITY
Co-57	122keV	2 pico Curie
Ce-139	165keV	3 pico Curie
Cs-137	662keV	6 pico Curie
Co-60	133keV	10 pico Curie

Ge(Li) COMPTON SUPPRESSION SPECTROMETER

When the ultimate in low level counting is required, a Compton Suppression Spectrometer is the answer. In this system, the Ge(Li) detector is surrounded by an active NaI(Tl) or plastic guard detector as well as by an inert shield. A spectrum is accumulated with coincident signals from the two detectors arranged to gate off the MCA, thereby rejecting photons which scatter, leaving only part of their energy in the Ge(Li).

It should be pointed out that some radioisotopes (those having coincident gamma rays) such as Co-60, will not be analyzed properly by the anticoincidence spectrum from such a spectrometer. Therefore, two spectra are usually obtained from such a spectrometer – one in the anti-coincidence mode, and other in the normal (ungated) mode.

One such Compton Suppression Spectrometer implemented with Canberra electronics is illustrated in Figure 41.

One type of annulus has six (6) 2" PM tubes on one end and a 3' NaI(Tl) plug with one PM tube which is operated in parallel with the other PM tubes. A simpler type is a 6" diameter NaI(Tl) crystal on a single PM tube, with a well for the Ge(Li) detector.

The timing signals are derived from the Model 2037A Timing SCAs operating in discriminator crossover mode with bipolar pulses from the Model 2021 Amplifiers.

The 2040 Coincidence Output goes to a Model 1454 Linear Gate and Stretcher so that when coincidence occurs it gates OFF the signal from the Model 2021. Details of coincidence circuits are described in the following section.

Some results obtained with Compton Suppression are illustrated in Figure 42.

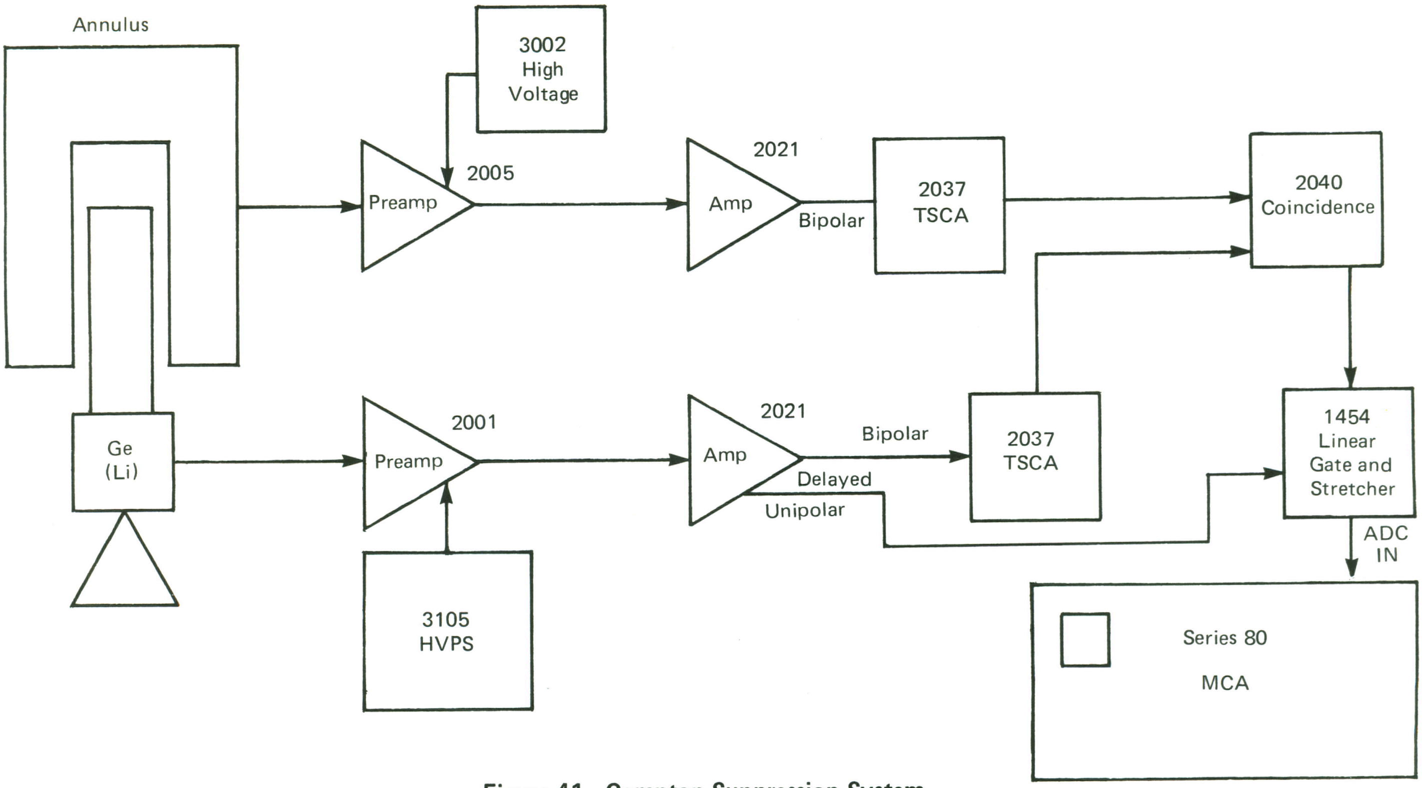

Annulus
3002
High
Voltage
2005
Preamp
2021
Amp
Bipolar
2037
TSCA
2040
Coincidence
Ge
(Li)
2001
Preamp
2021
Amp
Bipolar
Delayed
Unipolar
2037
TSCA
1454
Linear
Gate and
Stretcher
ADC
IN
3105
HVPS
Series 80
MCA

Figure 41. Compton Suppression System.

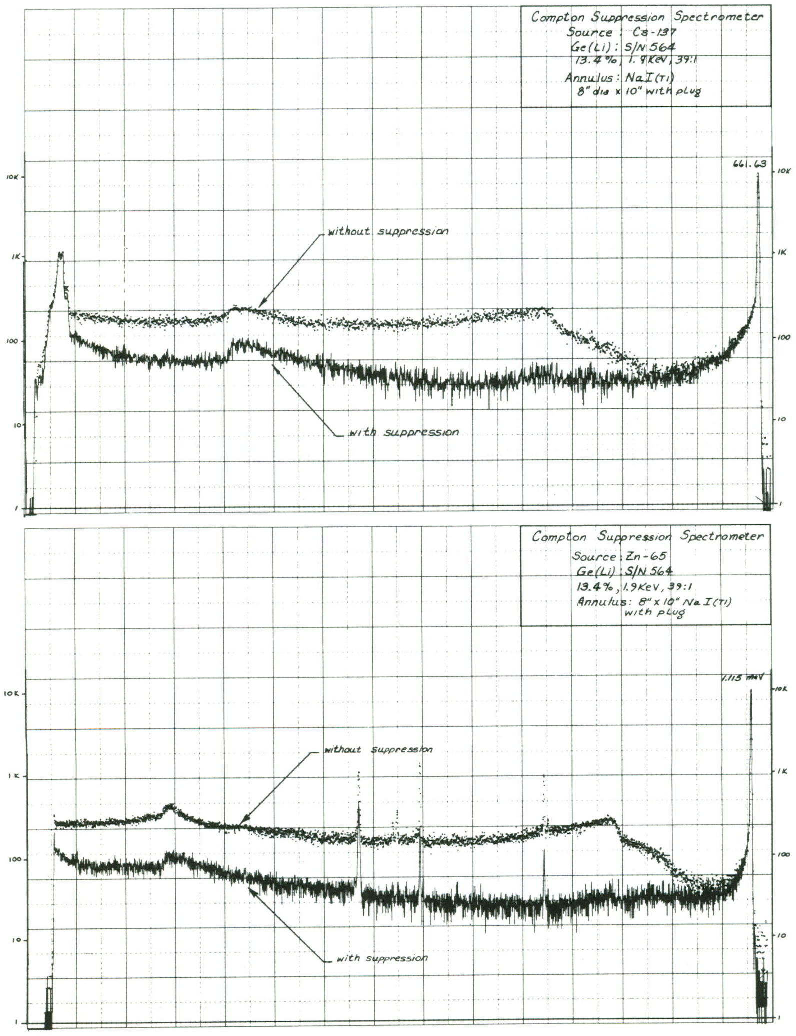


Figure 42. Ge(Li) Spectra with Compton Suppression.

LOW LEVEL ENVIRONMENTAL ALPHA AND BETA MEASUREMENTS

Many environmental concerns, such as low levels of ^{226}Ra in drinking water, require measurements of alpha or beta radiation at such low levels as 1 picoCurie per liter. The large area of a gas proportional counter provides a convenient means of measuring large area samples such as 2" diameter filter paper from an air sampling unit or a 2" planchette on which a liquid has been evaporated to form a solid residue. Both Alpha and beta particles can be detected, and can even be separated to provide simultaneous counting of separate levels of alpha and beta activity.

In the Canberra Alpha/Beta System, which is described in detail in the Systems Section of this catalog, a flat "pancake" proportional counter is located very close to the sample position. Alphas and betas are not stopped in the thin window detector, but leave an ionization density that is much larger for alphas than betas. This operates like the dE/dx counters described earlier for surface barrier detectors. Discriminator levels of an SCA can be set above noise for the LLD and above the beta but below alpha signals to produce an SCA output pulse for betas and a ULD pulse for alphas. The block diagram for such a system is shown in Figure 43.

The sample detector is part of a combined unit also containing a "cosmic detector". This cosmic or guard detector is used to reduce background from cosmic rays that would pass through both detectors. The event in the cosmic detector is used to gate off both alpha and beta scalers. Significant background reductions are accomplished with this anti-coincidence arrangement.

HIGH COUNT RATE GAMMA RAY SYSTEMS

Special techniques are required to count gamma rays at high rates and maintain good resolution. Preamplifiers must have a large voltage range in order to avoid saturation if many pulses are located on the decay times of earlier pulses. Amplifiers must have low peak shift and broadening with count rate, which depends primarily upon the baseline restorer. The ADC should also have a small dead time so that many counts are not lost just because the ADC is still processing an earlier pulse.

Low-energy gamma rays or X-rays have been mentioned earlier in the X-ray panel (see Figure 40).

For NaI, an excellent high count rate system consists of the 2007P preamp and the 1411 Double Delay Line (DDL) Amplifier with short (200 nanosecond) delay lines (see Figure 46). The 1411 DDL Amplifier has excellent overload recovery characteristics, so that the high pulse pileup that can occur does not persist over any long time. With a 0.4 microsecond delay line, the 1411 will recover from a 500 times overload in less than 2.5 microseconds. This amplifier has been used in NaI counting applications at count rates up to 500,000 Hz.

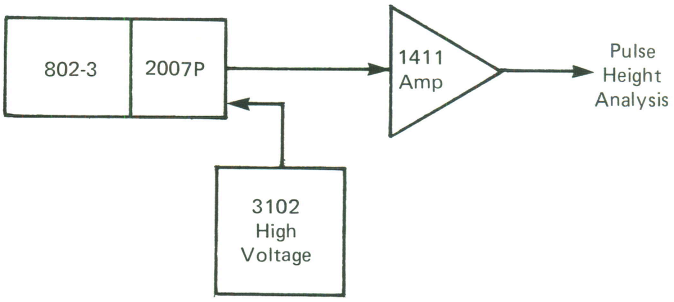


Figure 44. High Count Rate NaI System.

High count rate Ge(Li) systems pose far more stringent conditions because the resolution must also be maintained. Very low noise preamplifiers and amplifiers with high gain were developed specially for Ge(Li) detectors, and must be able to maintain those characteristics as the count rate increases. Canberra is the leader in providing capabilities with count rate specifications for peak shift and broadening given at rates of 100kHz for the 2021 Amplifier and 70kHz for the 2011 Amplifier. The 2021 Amplifier is successfully used in counting rates of up to 200kHz.

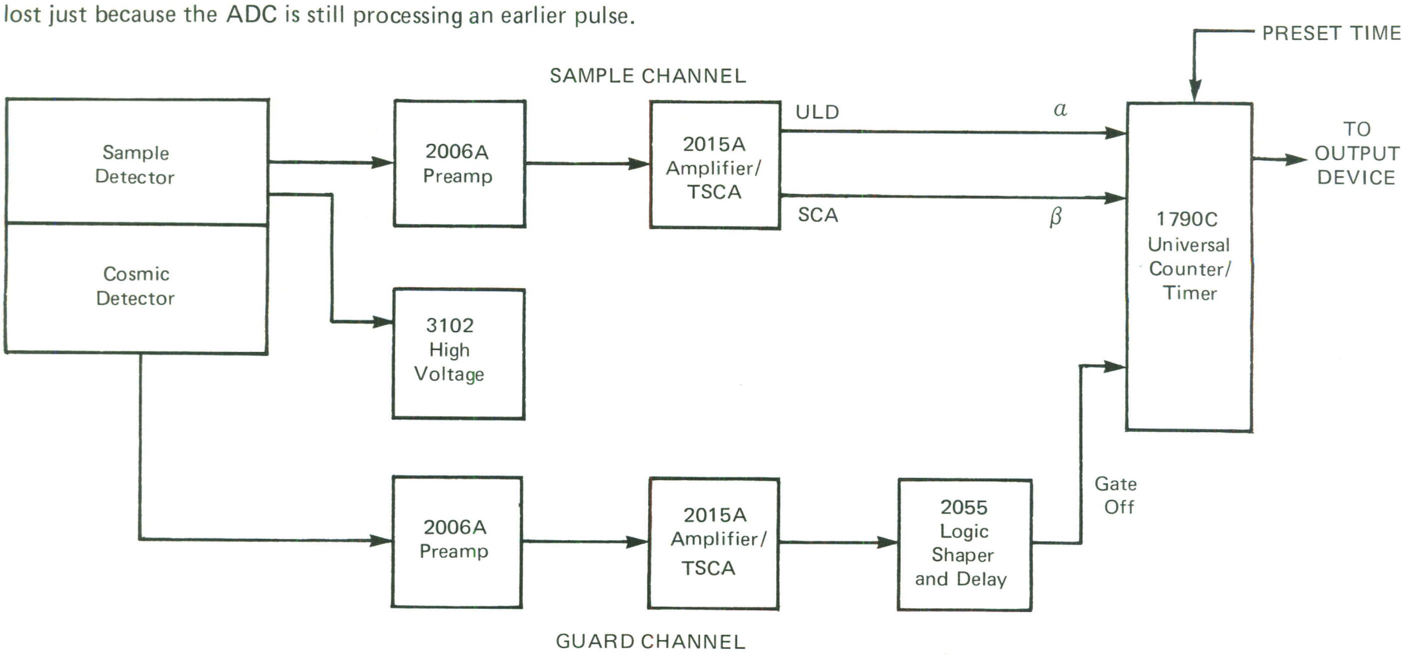


Figure 43. Low Level Alpha/Beta Counter.

The high resolution of the Ge(Li) detector requires many channels in the ADC and multichannel analyzer or computer-based analyzer, and the dead time of an ADC is higher as the channel number increases. For example, a 50MHz ADC requires (0.02 X channel number) microseconds, plus fixed processing time, to digitize a pulse. Channel 2000 then requires 40 microseconds plus fixed times, channel 4000 requires 80 microseconds, and so on. A higher clock rate, such as 100MHz, gives a factor of two improvement, but is still very long. Canberra has developed an ADC that utilizes successive approximation as well as the Wilkinson ramp technique to achieve dead times that are independent of channel number (up to channel 8192) for a maximum pulse processing time of 13 microseconds and an average of 9.5 microseconds. This is the 8080 Fast ADC described in the MCA Accessories Section and shown in Figure 45 with a Ge(Li) detector and 2021 Amplifier.

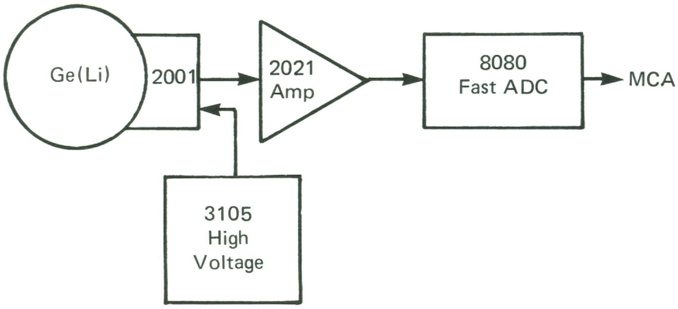


Figure 45. High Count Rate Ge(Li) System.

MOSSBAUER EFFECT

The observation of the Mossbauer Effect requires that a radioactive source and an absorber be moved at some velocity relative to each other, and through a Doppler shift of the energy

$E = E\gamma (1 + \frac{V}{C})$ a velocity spectrum can be recorded.

The principal components of a Mossbauer Effect Spectrometer are:

a.) gamma-ray detector and associated amplifier and high voltage power supply.

b.) a radioactive source mounted on a transducer which is driven by a module at calibrated velocities.

c.) a multichannel analyzer which is used to record the number of gamma-rays detected as a function of transducer velocity

d.) a function generator to control the transducer motion and synchronize the transducer to the multichannel analyzer.

Other components which might be used are devices to control the source and absorber environments such as cryogenics equipment.

The choice of detector depends on the type of Mossbauer study to be done. In most cases a thin (0.1 mm) NaI (Tl) crystal or a gas-filled Proportional Counter is suitable, but for special applications a pure germanium detector will be required. A complete range of detectors and accessories such as preamplifiers, amplifiers, single channel analyzers and detector bias supplies is available from Canberra, either NIM or as units incorporated in the MCA.

The source is mounted on a constant acceleration transducer, model 7426, which is provided with a feedback-controlled periodic signal from the drive unit, model 7427. Because the entire velocity range is covered in one cycle, many cycles are required to collect a spectrum in the MCA with a sufficiently small statistical error. Velocity limits of the 7427 are adjustable over the complete Mossbauer range, and for absolute calibration a laser interferometer can be provided which mounts directly on the transducer.

The driving waveform is supplied by the Model 7425 Function Generator and may be either the familiar triangular waveform, or a sinusoidal waveform for reduced transducer tracking error. The 7425 insures accurate synchronization between the transducer velocity and the MCA through the START MCS SWEEP and EXTERNAL CHANNEL ADVANCE signals, and the number of advance pulses per sweep is selectable by front panel switch to suit a wide variety of MCA memory sizes from 128 to 4096. A velocity region-of-interest mode is provided for accumulation of part of the velocity spectrum in the whole MCA memory.

Figure 45A shows a typical Mossbauer setup in which the detector output is processed by the internal amplifier and ADC of the multi-channel analyzer. The MCA is operated in multi-channel scaling mode, and the single-channel analyzer output of the ADC is counted at the MCS input. The count rate of the system is limited by the ADC conversion time, and may be improved by use of an external single-channel analyzer.

The collected spectrum is available for visual inspection on the MCA display, and may be recorded on any of a large number of peripheral devices. Further data analysis may be accomplished by computer processing, such as the Canberra Jupiter system.

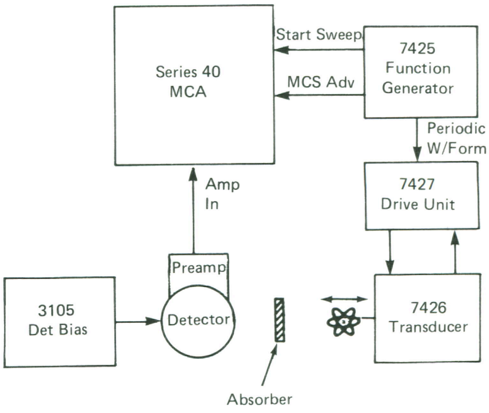


Figure 45A. A Typical Mossbauer System.

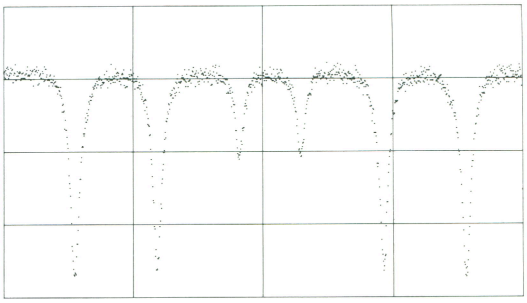


Figure 45B. Mossbauer Spectrum from ^{57}Co in Cu Source and Fe Foil.

Timing and Coincidence Counting Systems

COINCIDENCE TECHNIQUES

There are many applications in which it is necessary to measure an event in one detector that occurs at the same time as an event in another detector, or to obtain the time delay between two events. These two approaches are used in gamma-gamma or particle-gamma coincidence measurements, positron lifetime studies, lifetime studies and the like, and are described as coincidence or timing measurements.

The simplest coincidence system consists of a determination that two events occur within a certain fixed time. It is not possible to achieve perfectly simultaneous pulses because of the uncertainties or time jitter in determining when a pulse starts. A resolving time is specified in which a coincidence output occurs if the two pulses occur within the resolving time. The coincidence circuit is essentially a summing of two pulses with a discriminator level set so that output occurs only when the two pulses overlap, as shown in Figure 46. The resolving time is determined by the width of the pulses, τ, so that the resolving time is equal to 2τ. The Model 2040 coincidence operates in this fashion, but provides a constant shape output pulse when a coincidence occurs.

Accidental coincidences can occur between two pulses since detector events occur at random times, producing background in the coincidence counting. The rate of accidental or random coincidences is given by:

$$N_{acc} = N_1 N_2 \ (2\tau)$$

where N_1 and N_2 are the counting rates in the two detectors and 2τ is the resolving time of the coincidence circuit. The number of counts in the detectors depends upon the experiment and the detectors, so the best way to reduce accidental coincidences is to make the resolving time as small as possible. However, the resolving time cannot be reduced below the amount of time jitter in the detector pulses without losing true coincidences, so the type of detector determines the minimum resolving time usable.

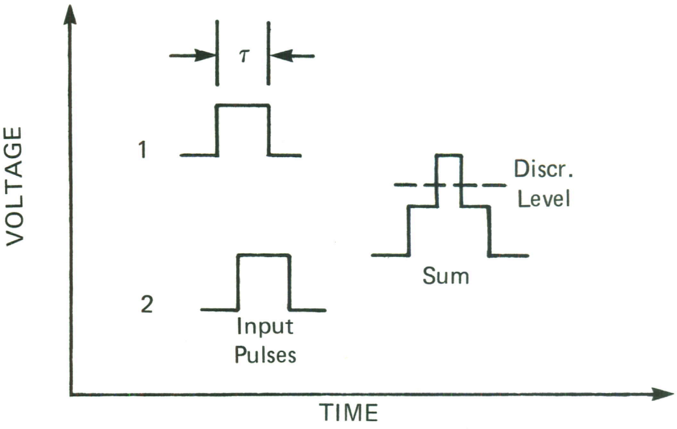


Figure 46. Coincidence Pulses.

A coincidence setup with NaI detectors is shown in Figure 47. The unipolar output pulse from the 2012 Amplifier is processed by a Model 2035A Constant Fraction Timing SCA to produce a standard NIM logic pulse for the 2040 Coincidence unit. The 807 Pulser is used to set up delays and test operation. In order to properly operate the system a delay curve is obtained in which coincidences are measured as a function of relative delay between the two detectors. In the

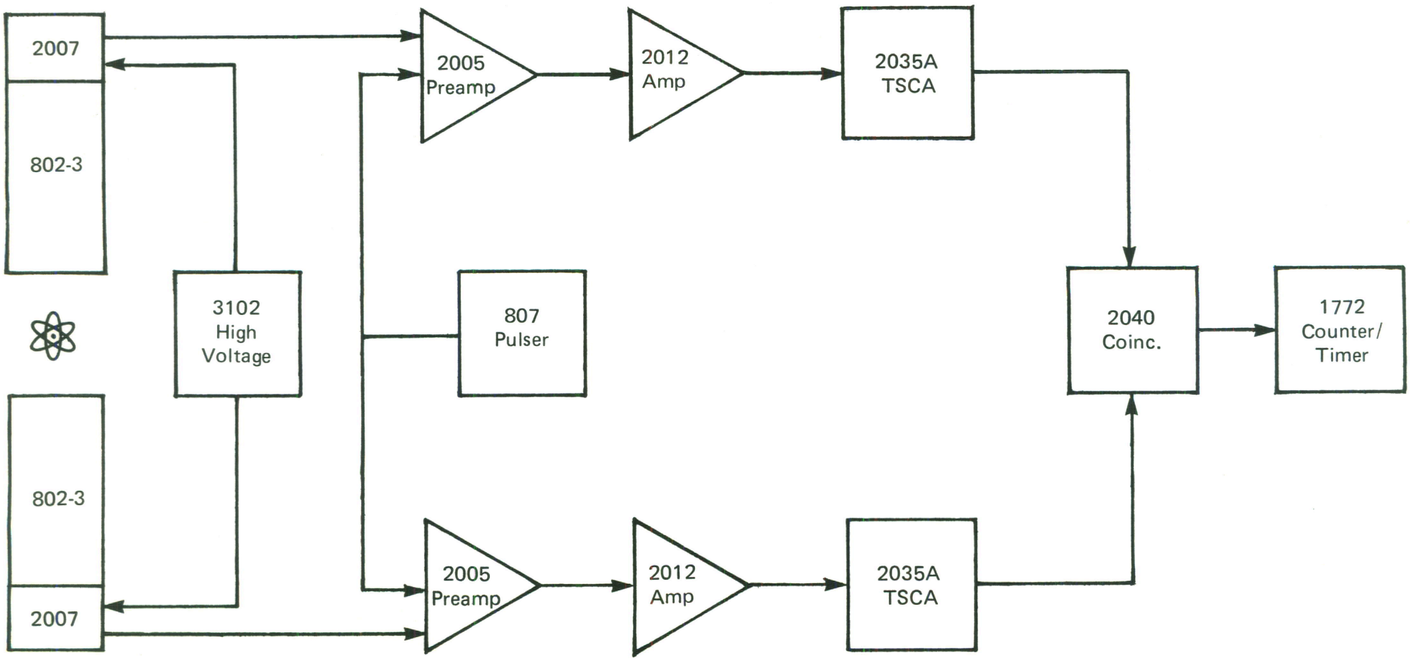


Figure 47. Coincidence Electronics.

ideal case of no time jitter in either detector, the solid curve in Figure 48 is obtained. However, real detectors will produce the dashed curve, and the minimum resolving time setting is where there is a flat region (indicating all true coincidences are collected). The proper relative delay is then the value for the center of the flat region.

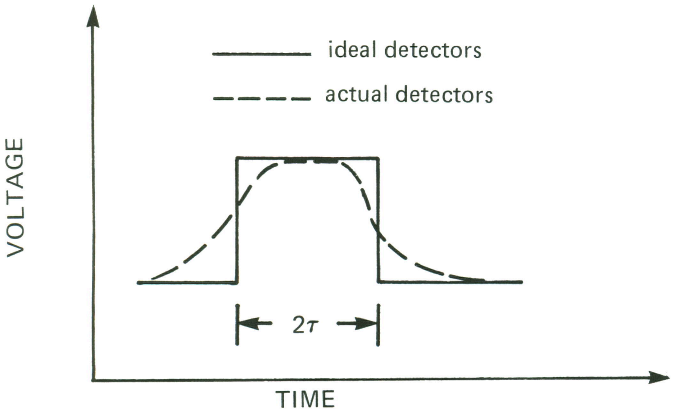


Figure 48. Resolving Time Curve.

Typical resolving times for NaI and Ge(Li) detectors are 100 nanoseconds for an energy range of 0.1 to 1MeV. Shorter resolving times are possible for plastic scintillators and surface barrier detectors, even down to less than 1 nanosecond. In general, the shorter the rise time of the preamplifier pulse, the smaller the resolving time. This is discussed further with fast discriminators below.

Another coincidence technique involves a direct measurement of the time delay between two pulses. A time-to-amplitude converter (TAC) or time analyzer converts a time difference to a 0 to 10 volt pulse that can be stored in an MCA or have a range selected by an SCA. The Model 2044 TAC has time ranges of 20 nanoseconds to 1 millisecond, and the Model 2043 provides an integral SCA capability as well as an output pulse, gate delays and other features.

The use of a 2043 TAC with NaI detectors in exact analogy with the 2040 Coincidence unit is shown in Figure 49. There are several advantages to the use of a TAC. First, no delay curve need be taken since all relative decays occurring are recorded, and second, no resolving time setting is involved. The natural time spectrum of the two detectors can be stored directly in an MCA, and a window can be set about the coincidence peak. If the window is set very narrow, as in Figure 50, then there are the minimum number of accidental coincidences recorded. The 2058 Nanosecond Delay unit is required to delay one detector pulse from the other so that a measureable time difference occurs.

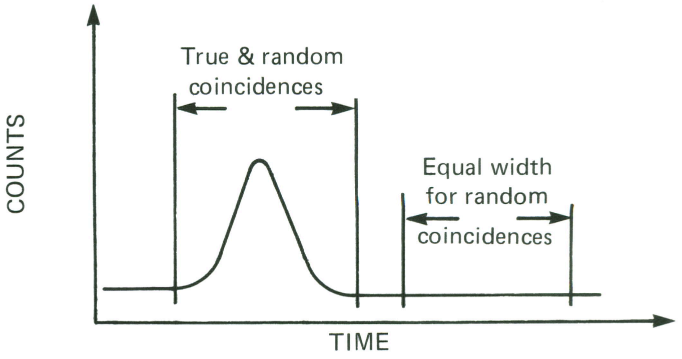


Figure 50. TAC Spectrum.

TIMING DISCRIMINATORS

A crucial part of the coincidence system is the timing discriminator used to determine when a pulse occurs. There are two general categories:

- Slow (or energy) Timing
- Fast Timing

The timing single channel analyzers used in Figure 47 and 49 are examples of slow timing. The single channel analyzer operates with shaped pulses to select the range of energies involved in the coincidence, and produces an output logic pulse that is, ideally, independent of input pulse amplitude. Fast timing uses pulses directly from the detector, without regard to specific energy.

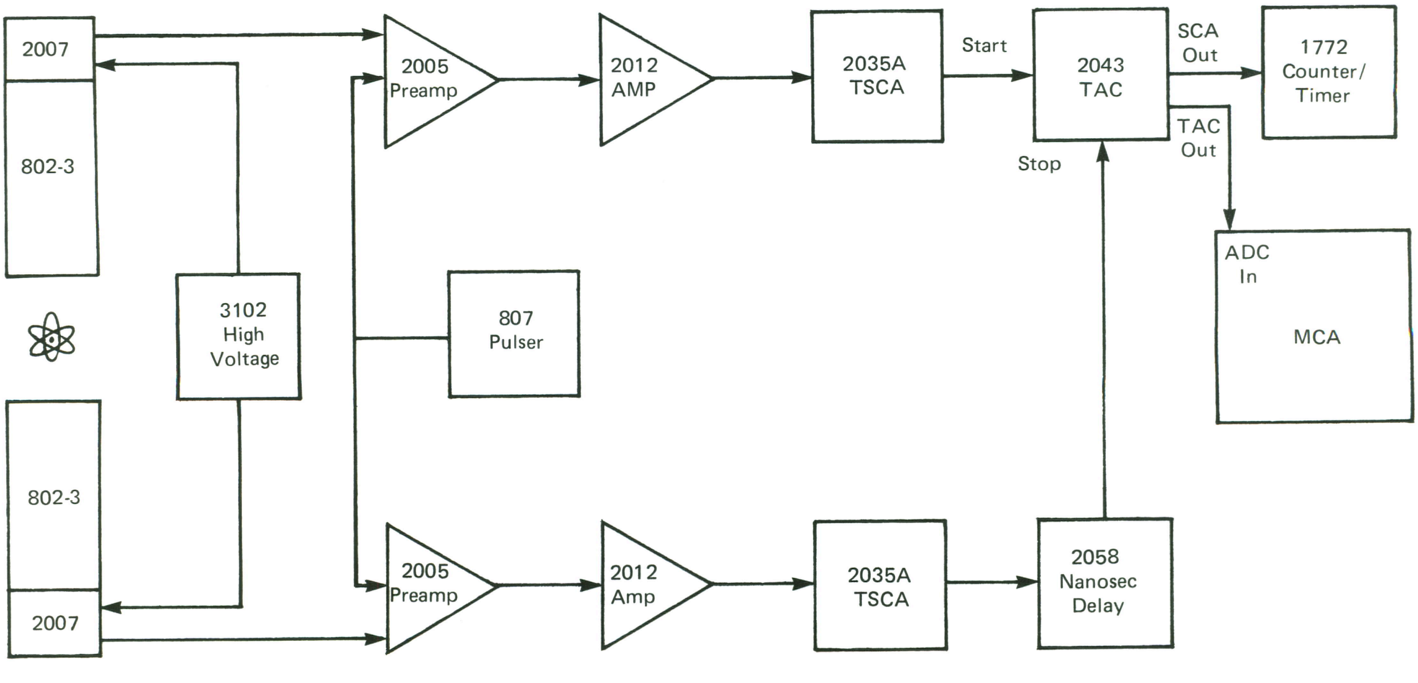


Figure 49. Coincidence Electronics with TAC Unit.

Three basic techniques are used in both fast and slow modes for acquiring timing information:

- Leading Edge
- Crossover
- Constant Fraction

Canberra provides electronic modules for performing any of these techniques, and the proper choice depends upon the detector and application, as discussed below.

Leading edge timing is the simplest, and consists of providing an output at the time the input pulse crosses through a discriminator level, as shown in Figure 51. The main problem is that the time of output pulse varies markedly with amplitude, as can be seen by comparing the two signals shown. This effect can be reduced by setting the discriminator at a very low level, such as just above noise. The Model 2037 Timing SCA sets the discriminator up to a maximum of 200 millivolts. Of course, for fast rise time pulses from a plastic scintillator or surface barrier detector, leading edge timing is an effective low-cost method.

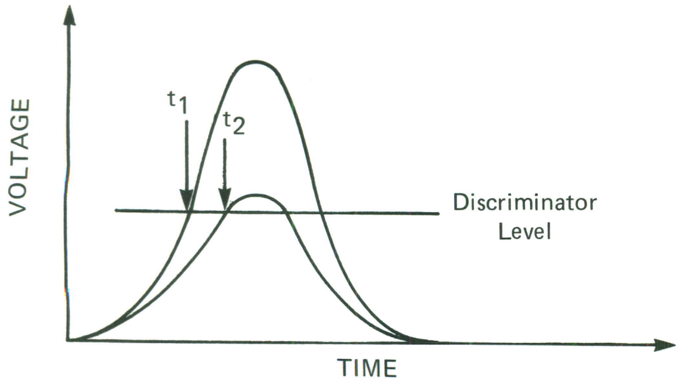

VOLTAGE
t_1
t_2
Discriminator Level
TIME

Figure 51. Leading Edge Timing.

Crossover timing relies on the fact that the zero crossing point in a bipolar pulse is very nearly independent of pulse amplitude. (See Figure 52). The Model 2037 Timing Single Channel Analyzer also has a crossover mode of operation for bipolar input pulses. Use of a 2037 Crossover Timing SCA with a 2011 Amplifier bipolar output pulses is shown in Figure 53. Also shown in Figure 53 is the collection of a coincidence spectrum from one detector in which the direct spectrum is gated on only when a coincidence pulse is present.

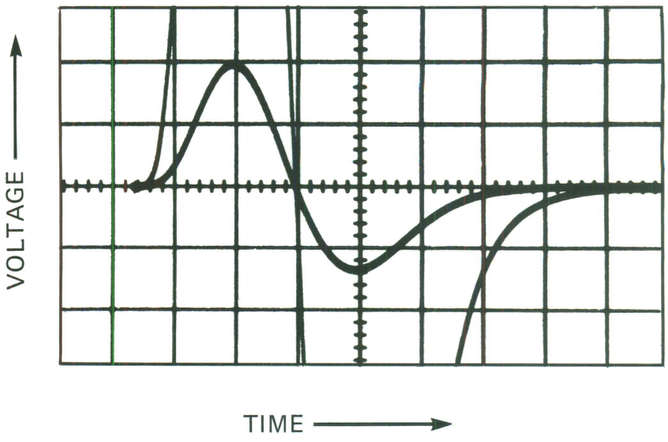


Figure 52. Bipolar Pulses and Crossover Timing.

The crossover technique has some limitations in that there is still time dependence or "walk" for different amplitudes, and that signals with varying rise times from the same detector, such as occurs with Germanium detectors, will produce walk.

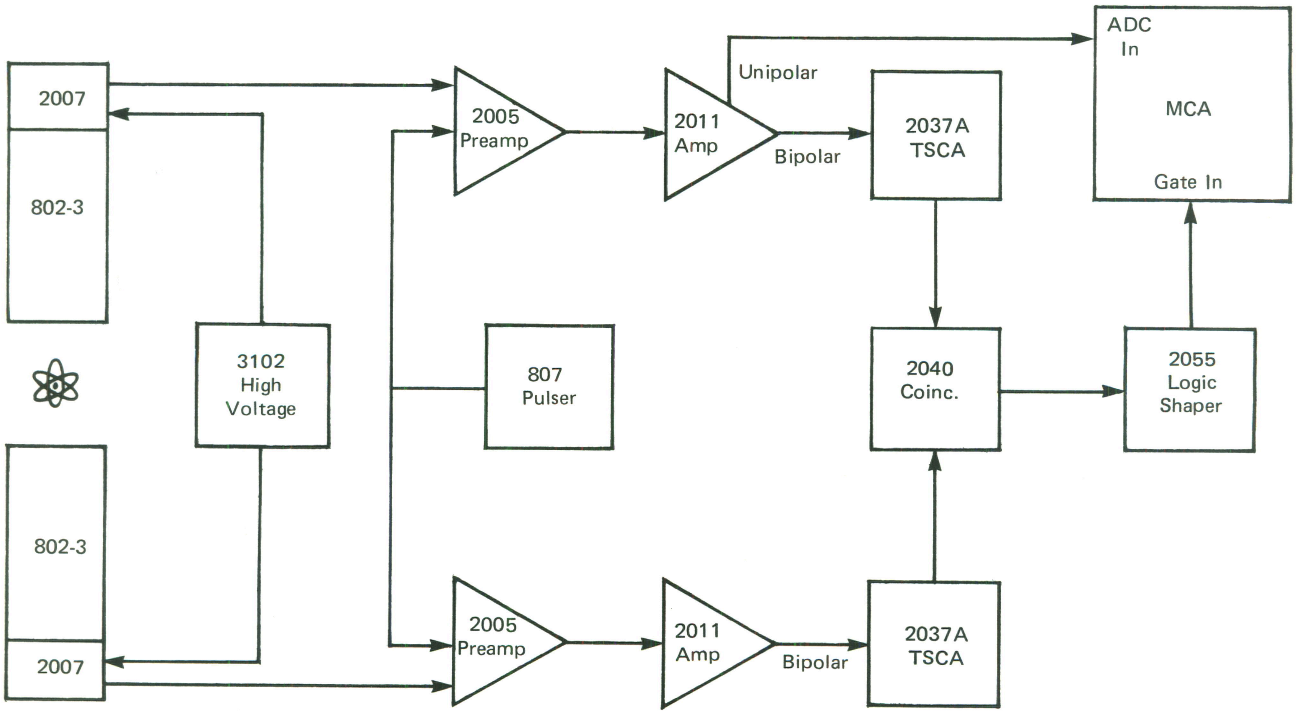

2007
802-3
3102 High Voltage
802-3
2007
2005 Preamp
807 Pulser
2005 Preamp
2011 Amp
Unipolar
Bipolar
2011 Amp
Bipolar
2037A TSCA
2040 Coinc.
2037A TSCA
ADC In
MCA
Gate In
2055 Logic Shaper

Figure 53. Coincidence Electronics with Crossover Timing.

The constant fraction technique will eliminate most of the shortcomings of the two former methods of timing. The constant fraction timing technique is similar to a discriminator with a threshold that is a constant fraction of the signal amplitude. A zero crossover can be derived by summing the original pulse and a delayed, inverted, and amplified version of the original pulse, as shown in Figure 54. All signals will cross through zero at the same time, independent of rise times or amplitudes. The actual procedure used in Canberra units is to form the difference signal between an attenuated input pulse and a delayed full amplitude input pulse, which is effectively the same process. Canberra presently offers several units using the constant fraction technique for better time resolution in spectroscopy applications. For slow coincidence work, the Model 2035A Timing SCA uses constant fraction timing on positive unipolar pulses from amplifiers such as the 2020, 2021, 2011, or 2012. (See Figures 49 and 53). For fast timing the 1428A constant fraction discriminator should be used.

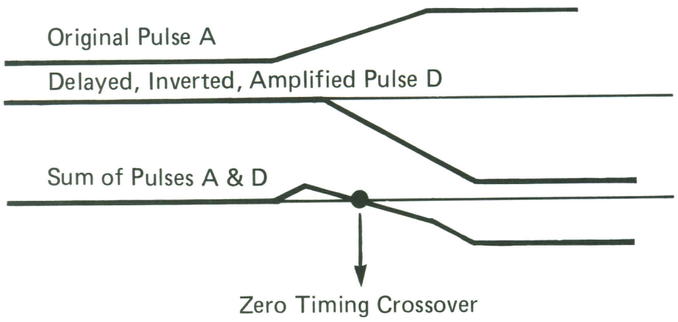


Figure 54. ARC Timing Internal Signals.

It can be connected to NaI or fast plastic detectors, or in general, with detectors having fast risetimes ($t_r \approx 1$nsec or greater) and good negative amplitude output signals (-5mV to -5V). The 1428A performs no signal processing on the input signal before analyzing it. It accepts only a negative input and is very often attached directly to the anode of a PM tube. As mentioned above constant fraction discrimination is a method that offers a timing output signal when a constant ratio of the pulse height is reached. This ratio, once set, is consistent from pulse to pulse, thus removing the amplitude and risetime errors that arise. The only actual downfall of this method is that it is still sensitive to pulse shape distortion and prone to jitter because of the crossover discrimination used in detection. Constant fraction discrimination alone exhibits rather poor time resolution for energies less than 200keV and for poorly shaped pulses.

The 2110/1428A combination has widespread application in gamma-gamma coincidence and lifetime studies. It exhibits excellent time resolution, which in connection with the high resolution of large Ge(Li) detector increases the rate of useful data collection.

The 2110 Timing Filter Amplifier unit is applicable for both surface barrier and Ge(Li) timing applications. Both of these detectors produce signals of low amplitude, distorted with noise, and in the case of Ge(Li) detectors, poorly shaped risetimes. Whenever noise is a significant characteristic of a detector, a filter network is required between the signal source and the amplifier to alleviate the noise distortion. The 2110 has a built-in filter that attenuates the noise component before amplification of the low signal. When used with a constant fraction discriminator such as the 1428A, a stable time reference can be derived.

A coincidence system with two plastic scintillators, such as might be used for positron lifetime measurements, is shown in Figure 55. In this case the Model 1428A Constant Fraction Discriminator is used to derive the timing information to produce inputs to the Model 2043 Time Analyzer for a time spectrum. The MCA is gated by a slow coincidence between pulses corresponding to selected energies in the two detectors. (A 1.27MeV gamma ray is present as well as the two 0.511MeV annihilation gamma rays, and the 1.27MeV gamma ray can be selected to indicate a time before the positrons are created.)

A gamma-gamma coincidence system with NaI and Ge(Li) detectors is shown in Figure 56. This is an example of a "fast-slow" coincidence system in which Model 2110 and 1428A constant fraction discriminators are used to indicate the presence of a pulse, and an energy range on the NaI detector is selected. The energy spectrum of the Ge(Li) detector is stored in the MCA if the ADC gate is opened by a coincidence pulse representing a combination of proper NaI-Ge(Li) timing and the selected NaI energy. A Model 2043 TAC is used to set the true coincidence range because of the set-up convenience offered, as described above. The TAC SCA output and the Timing SCA output of a Model 2015A Amplifier/Timing SCA are placed in coincidence with a Model 1446 Universal Coincidence. If desired, an energy requirement could be placed on the Ge(Li) detector by adding a Model 2037 Timing SCA on the 2021 Amp bipolar output and also feeding that to the Reset/Inhibit input on the 2043 Time Analyzer.

Anticoincidence systems are occasionally required, as mentioned above for Compton Suppression in Ge(Li) detectors (see Figure 41) or cosmic ray suppression in alpha/beta counting (see Figure 43). The techniques described thus far are applicable, but one must select the anticoincidence mode for a unit such as the 1446 Universal Coincidence or on the ADC gate.

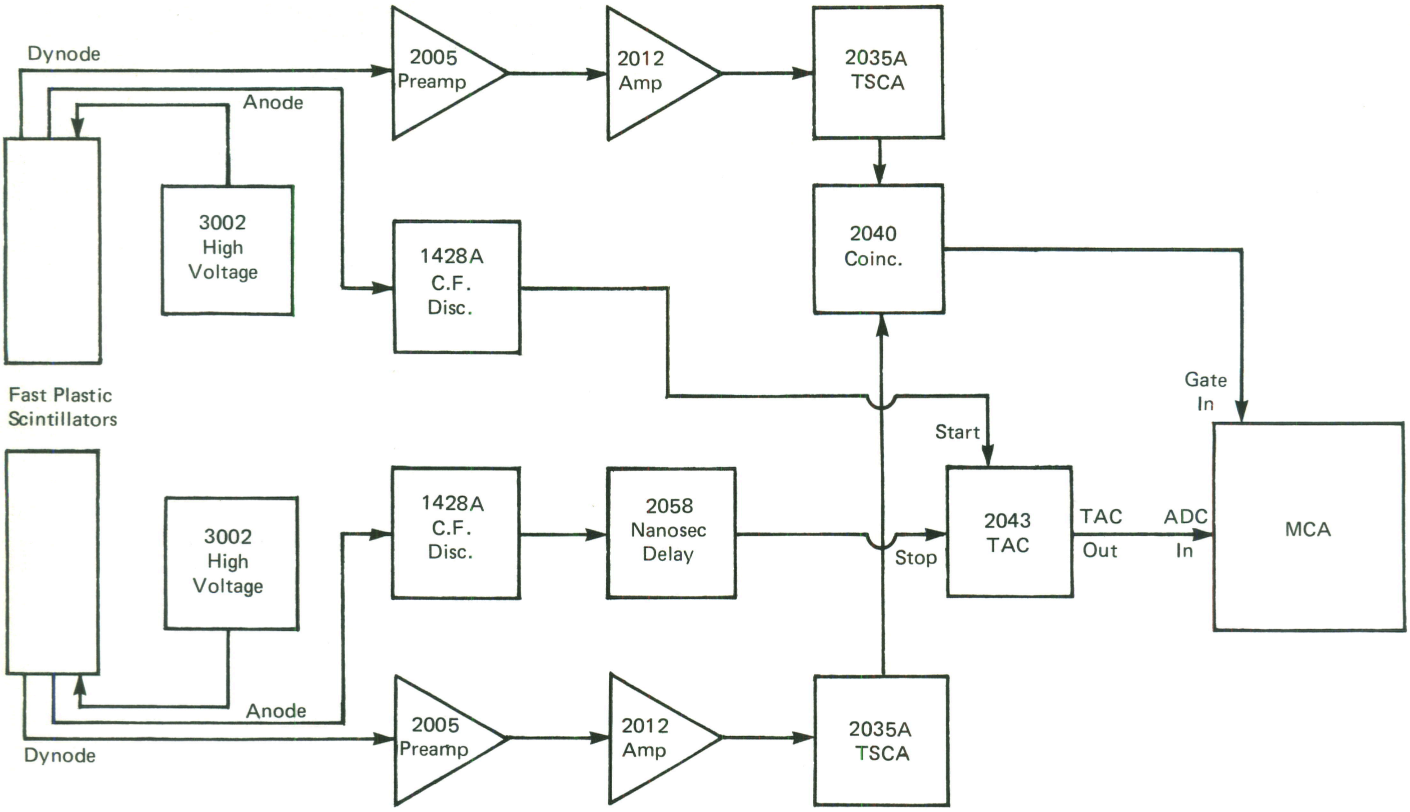

Dynode
Anode
2005 Preamp
2012 Amp
2035A TSCA
3002 High Voltage
1428A C.F. Disc.
2040 Coinc.
Fast Plastic Scintillators
Gate In
Start
1428A C.F. Disc.
2058 Nanosec Delay
Stop
2043 TAC
TAC Out
ADC In
MCA
3002 High Voltage
Anode
Dynode
2005 Preamp
2012 Amp
2035A TSCA

Figure 55. Positron Lifetime System.

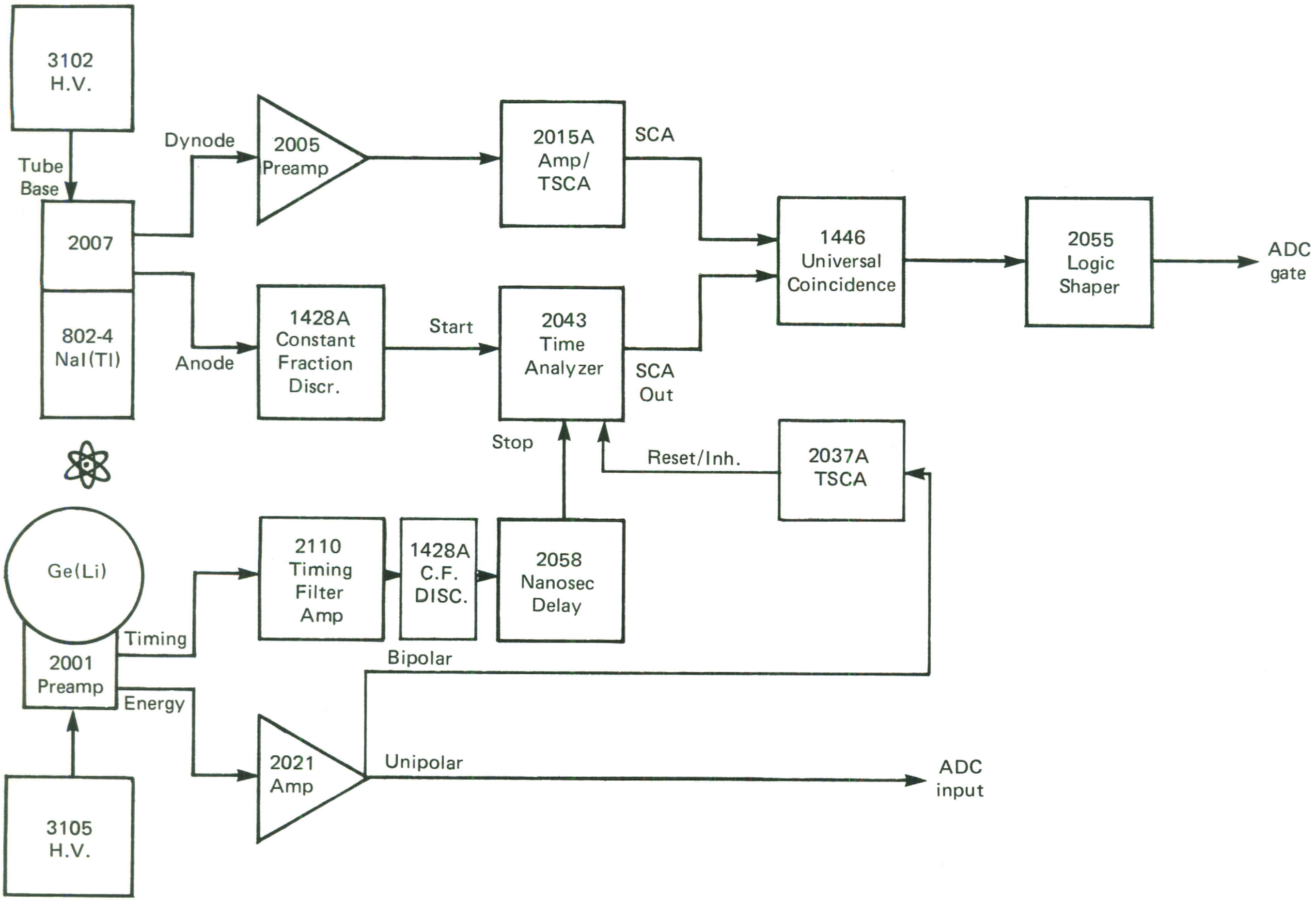

3102 H.V.
Tube Base
2007
802-4 NaI(Tl)
Dynode
Anode
2005 Preamp
2015A Amp/ TSCA
SCA
1428A Constant Fraction Discr.
Start
2043 Time Analyzer
SCA Out
Stop
1446 Universal Coincidence
2055 Logic Shaper
ADC gate
Reset/Inh.
2037A TSCA
Ge(Li)
2001 Preamp
Timing
Energy
2110 Timing Filter Amp
1428A C.F. DISC.
2058 Nanosec Delay
Bipolar
Unipolar
2021 Amp
ADC input
3105 H.V.

Figure 56. NaI-Ge(Li) Fast-Slow Coincidence Electronics.

MULTI PARAMETER AND EVENT RECORDING

Many experiments that use a fast-slow coincidence system, such as is shown in Figure 56, require a full spectrum from one detector in coincidence with more than one energy range in the other detector. This can mean repetition of the entire experiment with just a different setting of the SCA window. Multiparameter systems, such as the Canberra Series 88/MP analyzer and Model 8634 Data Acquisition Controller, provide a means for obtaining all energy ranges in one detector in coincidence with all energy ranges in the other detector. One can acquire all of the data, then examine the regions of interest.

An NaI gamma-gamma dual parameter system is shown in Figure 57. The coincidence determination is made with the external logic modules as shown, rather than using the Model 8634's Internal Coincidence Gating feature. The appropriate bits from each ADC are selected by the Model 8634's Patch Panel to provide a 64 x 64 or other data array, with a total of up to 16,384 locations (128 x 128). The data obtained can be visually interpreted as shown in Figure 58.

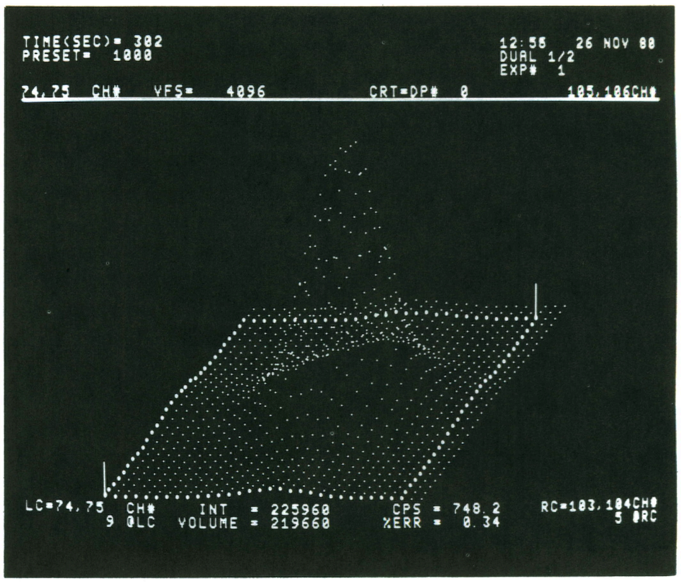

TIME(SEC)= 302
PRESET= 1000
12:56 26 NOV 80
DUAL 1/2
EXP# 1
74,75 CH# YFS= 4096
CRT=DP# 0
105,106CH#
LC=74,75 CH#
9 @LC
INT = 225960
VOLUME = 219660
CPS = 748.2
%ERR = 0.34
RC=103,104CH#
5 @RC

Figure 58. Dual Parameter Isometric Display.

The primary restriction to this technique is that the number of channels in the spectrum for each detector is limited by the size of the MCA's memory: for a 1024 x 1024 array, more than a million channels of memory would be required. To avoid this problem, the analyzer is used in the List mode, where the addresses of the coincident events are stored sequentially in memory and then recorded externally for computer analysis of selected portions of the data. This method is commonly referred to as event recording.

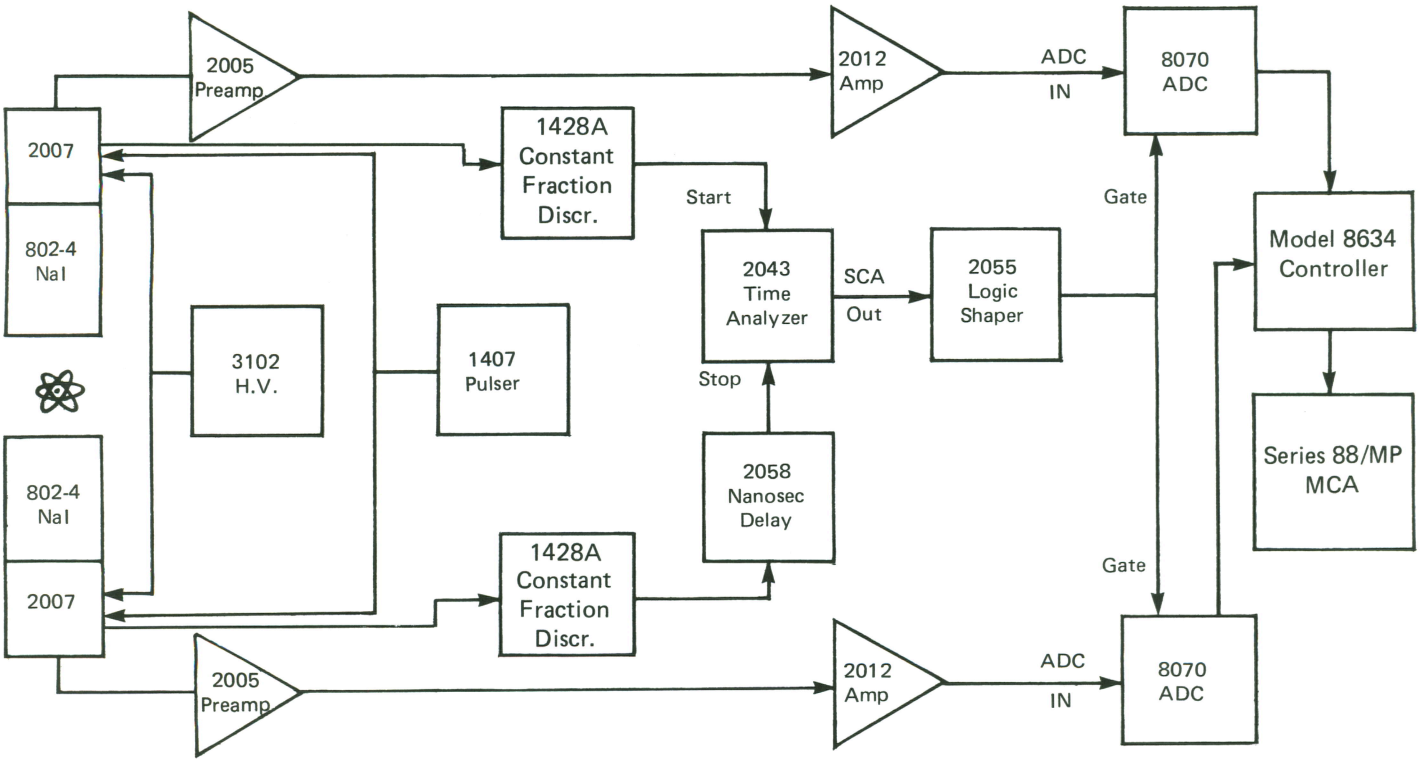

2005
Preamp
2012
Amp
ADC
IN
8070
ADC
2007
1428A
Constant
Fraction
Discr.
Start
Gate
802-4
NaI
2043
Time
Analyzer
SCA
Out
2055
Logic
Shaper
Model 8634
Controller
3102
H.V.
1407
Pulser
Stop
802-4
NaI
2058
Nanosec
Delay
Series 88/MP
MCA
Gate
2007
1428A
Constant
Fraction
Discr.
2005
Preamp
2012
Amp
ADC
IN
8070
ADC

Figure 57. Dual Parameter Experiment Using the Series 88 Multiparameter System.

The Series 88/MP analyzer system can accommodate up to eight independent ADC inputs and route the incoming data to one or more of the following data storage modes: Dual Parameter, PHA, MCS and List. In addition, the Dual Parameter mode can be configured as the Spectrum Multiscale mode. As an example of the additional flexibility offered by the Series 88/MP system, the Model 2043 Time-to-Amplitude Converter (TAC) output can be added to the event recording process, thus creating a three-parameter system, as shown in Figure 59. The SCA window is set wide to cover the entire TAC range and is used to gate the ADCs. The actual time window can then be selected during the data analysis, avoiding any possible errors in initial setup.

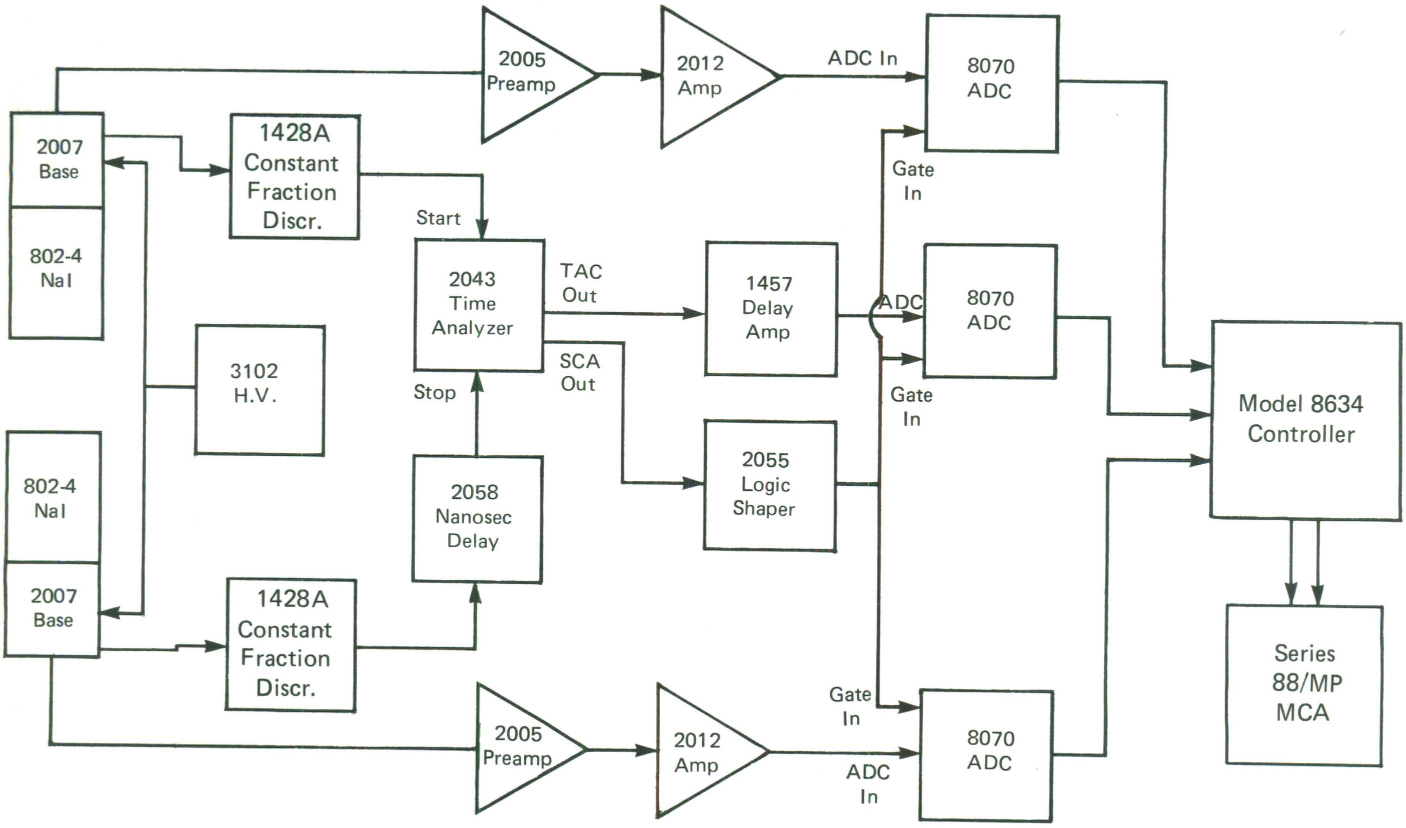

2005 Preamp
2012 Amp
ADC In
8070 ADC
2007 Base
1428A Constant Fraction Discr.
Gate In
802-4 NaI
Start
2043 Time Analyzer
TAC Out
1457 Delay Amp
ADC
8070 ADC
SCA Out
Gate In
Model 8634 Controller
3102 H.V.
Stop
2055 Logic Shaper
802-4 NaI
2058 Nanosec Delay
2007 Base
1428A Constant Fraction Discr.
Series 88/MP MCA
Gate In
2005 Preamp
2012 Amp
8070 ADC
ADC In

Figure 59. Three-Parameter Coincidence System.

Data Analysis

Canberra Industries has many systems which perform data analysis as well as collect data. These range from simple functions like summation of groups of channels in the Series 30 MCA to spectrum stripping and isotope identification in the Series 80 MCA to highly sophisticated special purpose systems such as the Jupiter (Series 80 MCA plus computer), the Body Burden system, and the Nuclear Waste Assay System. Details on the operation of these are given in the MCA and System sections, but we present here some of the common procedures involved.

COUNTING STATISTICS

Nuclear decay processes occur randomly in time so that a measurement made of a number of events in a given time is not exact, but represents an average value with some uncertainty. Better values of the average can be obtained by recording events over a longer time, but since this is not always possible it is necessary to be able to estimate the accuracy of any given average. Nuclear events follow a Poisson distribution, which is the limiting case of the binomial distribution for an infinite number of time intervals, and which is very close to the Gaussian distribution when the number of observed events is large.

The Poisson distribution for observing N events when the average is $\bar{N}$ is given by:

$$P_N = \frac{\bar{N}^N \; e^{-\bar{N}}}{N!}$$

and has a standard deviation σ equal to $\sqrt{\bar{N}}$. A graph of P_N for N equal to 3 and to 10 is shown in Figure 60. The curves are asymmetric and have the property that N is not exactly the most probable value but is close to it. However, as N increases the curve becomes more symmetric, and approaches the Gaussian distribution:

$$P_N = \frac{1}{\sqrt{2\pi\bar{N}}} e^{-X^2/2\bar{N}} = \frac{1}{\sqrt{2\pi\sigma}} e^{-X^2/2\sigma^2}$$

where X is equal to $N-\bar{N}$.

The integral of the area under the Gaussian curve is often used to report errors in terms of a confidence level in percent. For example, in the value reported as 64 ±8, 8 is equal to σ and represents 68% of the area under the appropriate Gaussian curve for N = 64. It may be stated as the value one is 68% confident of obtaining if the measurement is repeated. Canberra uses 1.65 σ in the Series 80 and SPECTRAN gamma analysis programs, corresponding to 90% confidence level. Probable error is often used, which corresponds to a 50% confidence level. These can be user-set at other values, such as shown below:

Number of σ	% Confidence
0.68	50
1.0	68.3
1.15	75
1.65	90
1.96	95

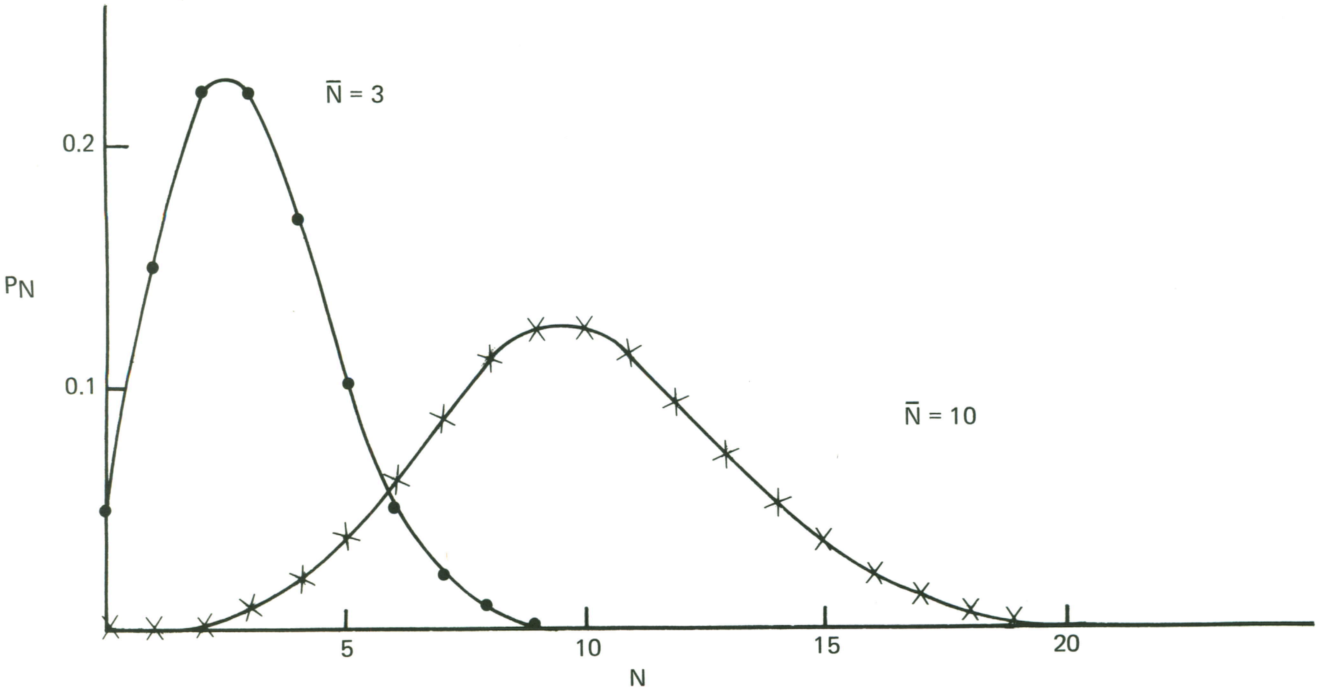


Figure 60. Poisson Distributions for N = 3 and 10.

Since the uncertainty depends upon the square root of the counts, improvements in accuracy by counting longer or by using a more efficient detector only go as the square root. For example, if 564 counts are obtained in an hour for $\sigma = \sqrt{564} \cong 24$ for a 24/564 = 4.3% accuracy, counting for two hours to get 1133 counts with $\sigma \cong 34$ only gives an improvement to 3.0%. In other words, counting twice as long gives an improvement of $\sqrt{2} = 1.4$, or 40%.

Examples of counting statistics in actual data are the counts in a scaler, the counts in a single channel of an MCA spectrum, or the sum of counts in a group of channels in an MCA spectrum. The situation becomes more complicated when subtracting a background. Let us discuss two separate but frequent cases.

- Subtracting background counts, as in one scaler value from another, or for each channel when subtracting one spectrum from another.
- Subtracting a straight line background from a peak on top of a background in a spectrum, such as a Ge(Li) peak on top of Compton pulses from higher energy gamma rays.

The error in adding or subtracting two numbers with errors, as in:

$$N_{total} = \left(N_1 \pm \sqrt{N_1}\right) \quad \pm \quad \left(N_2 \; + \; \sqrt{N_2}\right)$$

is given bv:

$$N_{total} = \sqrt{\left(\sqrt{N_1}\right)^2 + \left(\sqrt{N_2}\right)^2} = \sqrt{N_1 + N_2}$$

Consider a low level counting situation in which 56 counts are obtained in 10 minutes, and a background of 38 counts in 10 minutes was measured without the sample. The result is 56 - 38 = 18 counts, with an error of $\sqrt{56 + 38} = \sqrt{94} = 9.5$, a σ value of 50%! And yet the original value is accurate to $\sqrt{56}$ or 7.5/56 = 15%. A better procedure is to measure the background over a longer period of time to obtain a small percentage error and factor to the appropriate time for each sample analyzed. Of course, this assumes the background to be constant for each of the samples, which can be checked.

NET AREA CALCULATION

For the second case, in which a peak lies on a background that cannot be subtracted by a background spectrum, such as shown in Figure 61 for an MCA spectrum from a Ge(Li) detector:

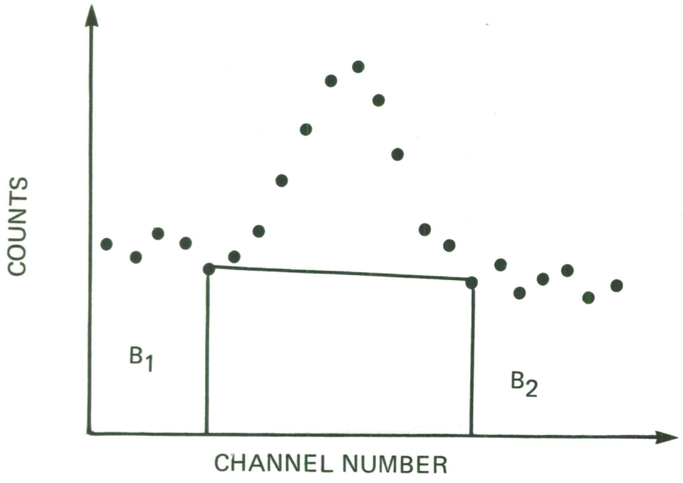


Figure 61. Net Area Determination.

The area above the background represents the total counts between the vertical lines minus the trapezoidal area below the straight line. If the total counts are T and the endpoints of the straight line are B_1 and B_2, then the net area is given by:

$$A = T - \frac{n}{2}\left(B_1 + B_2\right)$$

where n is the number of channels between B_1 and B_2.

It is tempting to calculate the uncertainty by just using the formula for subtracting two numbers, with standard deviations of $\sqrt{T}$ and $\sqrt{\frac{n}{2}\left(B_1 + B_2\right)}$ to obtain $\sqrt{T + \frac{n}{2}\left(B_1 + B_2\right)}$. However, this is incorrect because the error in the trapezoidal area is not just the square root of the counts, but depends upon how the errors in B_1 and B_2 effect the straight line across the entire region. The proper procedure, which is implemented in the Series 80 MCA and in analysis of peak areas in SPECTRAN, body burden and waste assay programs, is derived as follows:

> The standard deviation in a function A is given by: $A = f(N_1 \; N_2 \ldots N_n)$ where $N_1 \ldots$ are counts in the n channels.

The estimate of the standard deviation in A is given by:

$$\sigma(A) = \left[\left(\frac{\partial f}{\partial N_1}\right)^2 \sigma^2(N_1) + \cdots \left(\frac{\partial f}{\partial N_n}\right)^2 \sigma^2(N_2)\right]^{1/2}$$

$$= \left[1 \times \left(\sqrt{P_1}\right)^2 + \cdots \left(\frac{n}{2}\right)^2 \left(\sqrt{B_1}\right)^2 + \left(\frac{n}{2}\right)^2 \left(\sqrt{B_2}\right)^2\right]^{1/2}$$

$$= \left[P + \left(\frac{n}{2}\right)^2 \left(B_1 + B_2\right)\right]^{1/2}$$

where $P_1, \ldots P_n$ are the channels in the peak (inside B_1 and B_2).

END-POINT AVERAGING

If the background is large compared to the peak area a better determination of background can be made by averaging over several channels. If B_1 is an average over n_1 channels and B_2 over n_2 channels, the area is then:

$$A = P - \frac{n}{2}\left(\frac{B_1}{n_1} + \frac{B_2}{n_2}\right)$$

and the standard deviation is:

$$\sigma(A) = P + \left(\frac{n}{2}\right)^2 \left(\frac{B_1}{n_1^2} + \frac{B_2}{n_2^2}\right)^{1/2}$$

Both the Series 80 MCA and the Jupiter run-time software perform end-point averaging, with user-selectable numbers of points.

DEAD TIME CORRECTIONS

All discussion thus far has ignored time and dealt only with counting statistics. However, most electronic devices have an associated dead time and can suffer counting losses if the count rate is appreciable. A simple example is a scaler with a low frequency response. A scaler with only a 2MHz capability will be dead for many pulses if the average rate is close to that since the random times of pulses will often be closer in time than the 0.5 microsecond pulse pair resolution. For scalers a simple solution is to use very high frequency scalers such as the Canberra 1770 to 1790C series with 25MHz frequency response.

Multichannel analyzers require much longer to process a pulse than a scaler, and have long dead times that depend upon the internal clock frequency for the ramp timing and the converted channel number. Very high clock frequencies are used: 50MHz in the Series 30, and 100MHz in the Series 40 MCA, and the Series 80 MCA. Even at 100MHz the dead time is a fixed time of several microseconds for pulse processing (peak detection) plus 0.01 n microseconds, where n is the channel number. Thus the ADC is dead and pulses will be lost.

To provide minimum dead time in pulse height analysis Canberra has developed the Model 8080 Fast ADC with an average dead time of 9.5 microseconds for any channel number. This unit combines successive approximation and ramp conversion techniques to achieve short conversion times and yet maintain good linearity.

Automatic correction for dead time is obtained by collecting data for a given "live time" on an internal MCA clock that is turned on only when the ADC is available for accepting pulses. Alternatively, the live time and dead time can be compared and a correction applied to the data. The Series 80 MCA stores live time and clock time in channels 0 to 1 of each spectrum collected to allow such corrections.

Additional dead time can occur in the system, such as when a pulse pileup rejector, like the Canberra NIM Model 1468A or the 8623 front end module in the Series 80 MCA, is used. These units reject piled up pulses, which then represents additional dead time of the system. The 1468A has provisions for additional busy time in the ADC line, while the 8623 is internally connected to provide full system dead time.

ENERGY CALIBRATION

Determination of the energy of each channel of an MCA spectrum can be performed on the MCA itself for the more sophisticated units available today. The Series 40 MCA has a two-point energy calibration to determine both offset and slope in the equation:

$$E = A \times (\text{Channel Number}) + B$$

so that energy vs channel number can be directly read out. The Series 80 and the computer-based gamma analysis systems provide two additional energy calibration features:

- First or second-order calibration
- Least squares fits to several points

Most preamplifier, amplifier and ADC systems are very linear and first-order energy calibration can properly describe the data. For example, a Canberra Ge(Li) detector with 2001 Preamplifier, 2021 Amplifier, and 8621 ADC on the Series 80 has nonlinearities less than ±0.05% for the preamplifier and amplifier, and ±0.025% for the ADC. The combined nonlinearity is then:

$$\pm\sqrt{(.05)^2 + (.05)^2 + (.025)^2} = \pm 0.075\%$$

This is still a very small number, but for a spectrum of 4000 channels, the low and high energy channels may be correct and leave a 0.00075 x 2000 = 1.5 channel uncertainty at channel 2000. A second-order term in the energy calibration can remove this in order to provide very accurate energy-channel calibration over the entire range, according to the equation

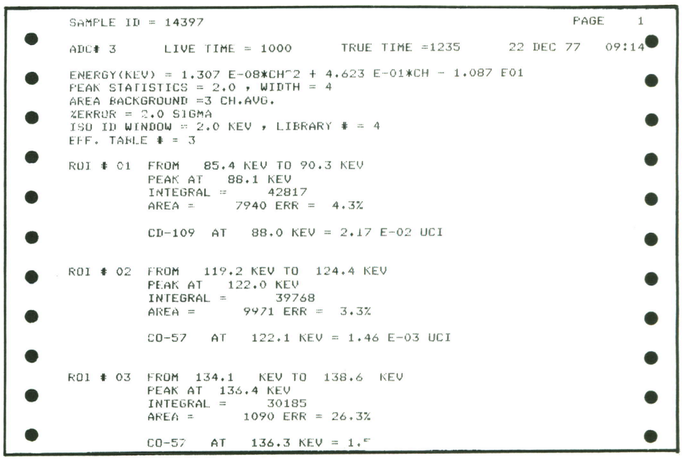
$$E = A\,(ch)^2 + B\,(ch) + C$$

where ch is channel number.

A further refinement is provided by using least squares fitting techniques to determine the best straight line through many points, or the best second-order curve, rather than using just the minimum 2 or 3 points for first or second-order. The Series 80 and the SPECTRAN gamma analysis programs provide least squares calculations for the coefficients in the energy calibration equations.

ISOTOPE IDENTIFICATION AND QUANTITATIVE ANALYSIS

Many applications with Ge(Li) detector spectra involve identifying particular gamma rays with specific isotopes. The sharp peaks in the Ge(Li) spectra, coupled with a careful precise energy calibration, can be used for generally unique determinations of the isotopes in a sample. If an automatic peak search capability is provided then a complete sample analysis can be carried out with no operator intervention, which is ideal for analyzing large numbers of samples. The Series 80 MCA and the SPECTRAN gamma analysis software in the JUPITER computer systems provide isotope identification, through peak searches in the spectrum and scans of standard and user-supplied isotope lists. A sample printout of a Series 80 isotope scan is shown in Figure 62.



```
SAMPLE ID = 14397                                              PAGE    1

ADC# 3      LIVE TIME = 1000      TRUE TIME =1235      22 DEC 77   09:14

ENERGY(KEV) = 1.307 E-08*CH^2 + 4.623 E-01*CH - 1.087 E01
PEAK STATISTICS = 2.0 , WIDTH = 4
AREA BACKGROUND =3 CH.AVG.
%ERROR = 2.0 SIGMA
ISO ID WINDOW = 2.0 KEV , LIBRARY # = 4
EFF. TABLE # = 3

ROI # 01  FROM   85.4 KEV TO 90.3 KEV
          PEAK AT   88.1 KEV
          INTEGRAL =      42817
          AREA =      7940 ERR =  4.3%

          CD-109  AT   88.0 KEV = 2.17 E-02 UCI


ROI # 02  FROM   119.2 KEV TO  124.4 KEV
          PEAK AT   122.0 KEV
          INTEGRAL =       39768
          AREA =       9971 ERR =  3.3%

          CO-57   AT   122.1 KEV = 1.46 E-03 UCI


ROI # 03  FROM  134.1   KEV TO  138.6  KEV
          PEAK AT  136.4 KEV
          INTEGRAL =      30185
          AREA =       1090 ERR = 26.3%

          CO-57   AT   136.3 KEV = 1.
```

Figure 62. Isotope Scan by Series 80 MCA.

In the Series 80 the peak search locates peak centroids and then enters a region of interest about the peak. This is especially useful for observing the quality of data obtained. The JUPITER software provides the additional capability of resolving overlapping peaks into individual components, even for multiplets with as many as five separate peaks.

The final step in isotopic analysis is to determine the intensity of the radioactivity corresponding to each isotope. The net area of the peak is directly related to the intensity, but it is also necessary to correct for the efficiency of the detector, the branching ratio of the source, and perhaps also the half life if it is desired to relate the activity back to an earlier time. The efficiency was discussed earlier and has an energy dependence such as shown in Figure 5. The branching ratio or yield is used to correct the number of gamma rays observed to obtain the number of disintegratons of the source. Figure 63 shows the decay scheme for ^{88}Y and the percent of disintegrations leading to the various gamma rays.

The activity of a particular isotope is thus given as (in microcuries):

$$\mu Ci = \frac{\text{Net Area}}{\text{Live time x Efficiency x Yield x } 3.7 \times 10^4}$$

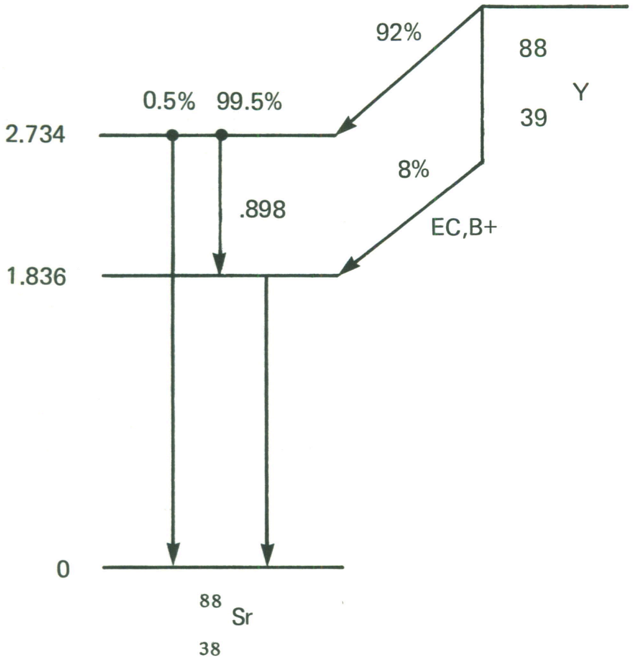


Figure 63. ^{88} Y Decay Scheme

where yield is the branching ratio fraction and live time is the actual ADC non-busy time. The factor 3.7 X 10^4 converts disintegrations per second to microcuries since 1 Curie = 3.7 X 10^{10} disintegrations per second. Half-life corrections are made by multiplying by an exponential factor.

$$\mu Ci \text{ at time } t_o = \mu Ci \times \exp\left(\frac{0.693 \times \text{Decay Time}}{\text{Half Life}}\right)$$

where decay time and half-life must be in the same units (seconds, minutes, hours, or years).

Further specific data analysis is highly dependent upon the application and detector and electronics configuration, and is beyond the scope of this brief presentation. Canberra Industries has extensive experience in providing complete systems for many different applications, and you are invited to contact us for assistance for your particular requirements.

DEFINE/USE

Multichannel Analyzers generally are used to collect and display raw data, and for applications demanding special analysis functions it is usually necessary to perform calculations either manually or by interface to a computer. The more sophisticated MCA's utilize pre-programmed specific functions, but a useful alternative is now provided, at a fraction of the cost of a fully-programmable system, in the model 4241 DEFINE/USE option, which is available for the Series 40 MCA.

Up to four algebraic equations can be defined, or loaded from a peripheral, by the Series 40 operator, which are continually evaluated (even during acquisition) and the results displayed on the screen and printed on the Report Header. Equations can be linked together, and can be saved by output to a peripheral for later re-introduction to the MCA. In defining an equation, the operator follows standard algebraic notation and hierarchy and has the following functions available

Square Root
Unary Minus
Multiply, Divide
Enter Exponent (10^N)
Add, Subtract

Floating point arithmetic is used, and paranthetical nesting is permitted. Constants may be defined or entered as literals, and variables may be specified as the Live Time or any of several types of data including the results of other equations. Each equation may be the length of a complete line text editor (58 characters) and the calculated results can be used to stop an accumulation at a predetermined value. Each time an equation is activated, an internal floating point register that can be used as an accumulator will be cleared. This register allows the operator to accumulate a running sum of the results of an equation, if desired.

An example of how the 4241 DEFINE/USE OPTION may be used is in count rate calculations. To compute an integrated count rate for MCA data it is only necessary to divide data by time, thus the equation to be defined is

EQ#N = V1 ÷ TL

where V1 represents the data and TL is the live time. By properly defining V1 the desired count rate can be determined, and in this case it is possible to determine the count rate in a specific channel or in a channel indicated by a cursor. Gross Count Rates or Net Count Rates above background for single or several peaks are other possibilities, and if more than one count rate measurement is desired then individual equations can be defined, each having a different assignment for the variable V1, and the operator can select the one desired at will. The operator may also make the selection between specified peaks, or regions of interest (ROI's), and those currently indicated by the location of a cursor.

Another example is the computation of dead time for a given set of data, the formula being:

$$\% \text{ Dead Time} = \frac{(\text{True Time} - \text{Live Time}) \times 100}{\text{True Time}}$$

To enter this in the 4241 via DEFINE the format is:

$$\text{EQ\#N} = ((\text{V1}-\text{TL}) \div \text{V1}) \times 100$$

where V1 is defined by the operator to be the data content in Channel #1 which is where the Series 40 stores the True Time.

The activity of a Peak, calculated in μCi, may be derived from

$$\frac{\text{Net Count Rate}}{\text{Efficiency} \times \text{Yield} \times \text{Disintegration Rate}}$$

Efficiency is the absolute efficiency of the detector system at the energy under study and yield is the gamma yield of the peak of interest. The equation to be defined in the Series 40 would be

$$\text{EQ\#N} = (\text{V1} \div \text{TL}) \div (\text{K1} \times \text{K2} \times 3.7\text{E}4)$$

Where V1 is defined by the operator to be the Net Area of the ROI under study and K1 and K2 are the efficiency and yield constants.

This particular example is both energy and isotope dependent due to Efficiency and Yield being entered as constants, but a significant amount of manual computation time can be saved for those applications requiring repetitive analysis of similar samples, and four separate equations can be defined for individual analysis without the need for re-programming.

An equation may be defined to calculate the percent error of a peak area within a given region of interest.

$$\%\text{ERR} = 165 \times (\text{INT} + ((\text{N}\div 2)^2 \ (\text{B1} + \text{B2})))^{1/2} \div (\text{INT}-((\text{N}\div 2) \times (\text{B1} + \text{B2})))$$

where INT = integral value of the ROI
N = number of channels in the ROI
B1 = contents of the last channel before the ROI
B2 = contents of first channel after the ROI

This equation may be entered in the Series 40 as:

$$\text{EQ\#1} = \text{K1} \times \sqrt{\ } (\text{V1}+(\text{K2}\text{x}\text{K2}\text{x}\text{V2})) \div (\text{V1} - (\text{K2} \text{ x } \text{V2}))$$

where K1 = 165 for 90% Confidence level
V1 = integral value of the ROI
K2 = (N÷2)
V2 = (B1 + B2)

B1 and B2 are variables which have to be entered as a separate equation. In this instance V2 = EQ#2 and this second equation can be defined as the sum of V1 and V2 which correspond to B1 and B2 of the first equation, thus showing how equations may be linked together. A third equation link is possible in this instance, by defining for example

$$\text{EQ\#3} = \text{K1} - \text{EQ\#1}$$

and if EQ#3 is used as a preset parameter, with the preset value chosen to be a suitable integer which is less than K1, the accumulation of a spectrum may be terminated when the statistical error of a specified peak area has fallen to a predetermined percentage.

Some of the other applications for the 4241 DEFINE/USE option include decay-corrected activity, percent effect for Mossbauer peaks, enrichment, original activity extrapolation, efficiency, dose rate and the radio-chemical component in radiochromatograph scans. It can be seen that the simple user-definition of algebraic equations facility of the 4241 greatly enhances the capabilities and usefulness of a comparatively inexpensive MCA. In particular, both throughput and accuracy can be greatly improved for routine repetitive measurements at quite modest cost.

REFERENCES

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4. R.D. Evans, *ibid.,* p. 637.
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SYSTEM SELECTION GUIDE

Application		Minimum Cost	Mid Range	Maximum Performance
Alpha Spectroscopy	Single Input	• SSB Detector • 7400 Vaccuum Chanber • 2004DM Preamplifier • 2012 Amplifier • 3102 HVPS • 2000 NIM Bin/Power Supply • 3100 Series 30 MCA	• SSB Detector • 7400 Vaccuum Chamber • 2004DM Preamplifier • 4201 Series 40 Processor • 4221 Amplifier/ADC • 3100-01 HVPS • 4241 Define/Use	• SSB Detector • 7400 Vaccuum Chamber • 2004DM Preamplifier • 2012 Amplifier • 3102 HVPS • 2000 NIM Bin/Power Supply • 8602A Series 80 Processor • 8621 ADC/SCA
	4 Inputs	• SSB Detectors, 4 ea. • 7404 Quad Alpha Spectrometer • 2004DM Preamplifier, 4 ea. • 2012 Amplifier, 4 ea. • 8220A Mixer/Router • 2000 NIM Bin/Power Supply • 3100 Series 30 MCA • 3100-06 Mixer/Router Wiring	• SSB Detectors, 4 ea. • 7404 Quad Alpha Spectrometer • 2004DM Preamplifier, 4 ea. • 2012 Amplifier, 4 ea. • 8220A Mixer/Router • 2000 NIM BIn/Power Supply • 4201 Series 40 Processor • 4221 Amplifier/ADC • 4231 Mixer/Router Wiring • 4241 Define/Use • 4242 Learn/Execute	• SSB Detectors, 4 ea. • 7404 Quad Alpha Spectrometer • 2004DM Preamplifier, 4 ea. • 2012 Amplifier, 4 ea. • 2000 NIM Bin/Power Supply • 8602A Series 80 Processor • 8624 ADC/Gated Mixer Router
	>4 Inputs	Not Available	• SSB Detectors, ≤ 16 ea. • 7404 Quad Alpha Spectrometer, ≤ 4 ea. • 2004DM Preamplifier, ≤ 16 ea. • 2012 Amplifier, ≤ 16 ea. • 8220 Mixer/Router, ≤ 4 ea. • 2000 NIM Bin/Power Supply, as required • 4202 Series 40 Processor • 4223 Multi-ADC Interface • 8075 100 MHz NIM ADC • 4241 Define/Use • 4242 Learn/Execute	• SSB Detectors, ≤ 16 ea. • 7404 Quad Alpha Spectrometer, ≤ 4 ea. • 2004DM Preamplifier, ≤ 16 ea. • 2012 Amplifier, ≤ 16 ea. • 2000 NIM Bin/Power Supply, as required • 8603A Series 80 Processor • 8683A Expansion Chassis • 8624 ADC/Gated Mixer Router, ≤ 4 ea.
NaI (Tl) Spectroscopy	Single Input	• NaI (Tl) Detector • 2007 Tube Base • 3100 Series 30 Processor • 3100-01 HVPS	• NaI (Tl) Detector • 2007 Tube Base • 4201 Series 40 Processor • 4221 Amplifier/ADC • 3100-01 HVPS • 4241 Define/Use	• NaI (Tl) Detector • 2007P Tube Base/Preamplifier • 3005R HVPS • 8602A Series 80 Processor • 8622 PHA/MCS
	2 - 4 Inputs <20K cps	• NaI (Tl) Detector, ≤ 4 ea. • 2007P Tube Base/Preamplifier, ≤ 4 ea. • 2012 Amplifier, ≤ 4 ea. • 3102 HVPS, ≤ 4 ea. • 8220A Mixer/Router • 2000 NIM Bin/Power Supply • 3100 Series 30 MCA • 3100-06 Mixer/Router Wiring	• NaI (Tl) Detector, ≤ 4 ea. • 2007P Tube Base/Preamplifier, ≤ 4 ea. • 2012 Amplifier, ≤ 4 ea. • 3102 HVPS, ≤ 4 ea. • 8220A Mixer/Router • 2000 NIM Bin/Power Supply • 4202 Series 40 Processor • 4221 Amplifier/ADC • 4231 Mixer/Router Wiring • 4241 Define/Use • 4242 Learn/Execute	• NaI (Tl) Detector, ≤ 4 ea. • 2007P Tube Base/Preamplifier, ≤ 4 ea. • 2012 Amplifier, ≤ 4 ea. • 3102 HVPS, ≤ 4 ea. • 2000 NIM Bin/Power Supply • 8603A Series 80 Processor • 8624 ADC/Gated Mixer Router
	2 - 4 Inputs High Count Rate	Not Recommended	• NaI (Tl) Detector, ≤ 4 ea. • 2007P Tube Base/Preamplifier, ≤ 4 ea. • 2012 Amplifier, ≤ 4 ea. • 3102 HVPS, ≤ 4 ea. • 8075 100 MHz NIM ADC, ≤ 4 ea. • 2000 NIM Bin/Power Supply • 4202 Series 40 Processor • 4223 Multi-ADC Interface • 4241 Define/Use • 4242 Learn/Execute	• NaI (Tl) Detector, ≤ 4 ea. • 2007P Tube Base/Preamplifier, ≤ 4 ea. • 2012 Amplifier, ≤ 4 ea. • 3102 HVPS, ≤ 4 ea. • 8075 100 MHz NIM ADC, ≤ 4 ea. • 2000 NIM Bin/Power Supply • 8603A Series 80 Processor • 8635 Multi-ADC Interface
Ge Spectroscopy	Single Input	• HPGe or Ge(Li) Detector with Preamplifier • 3005R HVPS • 3100 Series 30 MCA • 3100-02 Spectroscopy Amplifier	• HPGe or Ge(Li) Detector with Preamplifier • 4202 Series 40 Processor • 4221 Amplifier ADC • 4261 HVPS • 3100-02 Spectroscopy Amplifier • 4241 Define/Use	• HPGe or Ge (Li) Detector with Preamplifier • 3005R HVPS • 8604A Series 80 Processor • 8623 PHA/LTC with Spectroscopy Amplifier • 8643 ISO ID-Isotope Identification • 8644 ISO QUAN-Quantitative Isotopic Analysis
	2 - 4 Inputs	Not Recommended	• HPGe or Ge(Li) Detectors with Preamplifiers, ≤ 4 ea. • 2011 Spectroscopy Amplifier, ≤ 4 ea. • 3105 HVPS, ≤ 4 ea. • 8075 100 MHz NIM ADC, ≤ 4 ea. • 2000 NIM Bin/Power Supply • 4203 Series 40 Processor • 4223 Multi-ADC Interface • 4241 Define/Use • 4242 Learn/Execute	• HPGe or Ge(Li) Detectors with Preamplifiers, ≤ 4 ea. • 3105 HVPS, ≤ 4 ea. • 2000 NIM Bin/Power Supply • 8605A Series 80 Processor • 8683A Expansion Chassis • 8623 PHA/LTC with Spectroscopy Amplifier, ≤ 4 ea. • 8643 ISO ID-Isotope Identification • 8644 ISO QUAN- Quantitative Isotopic Analysis

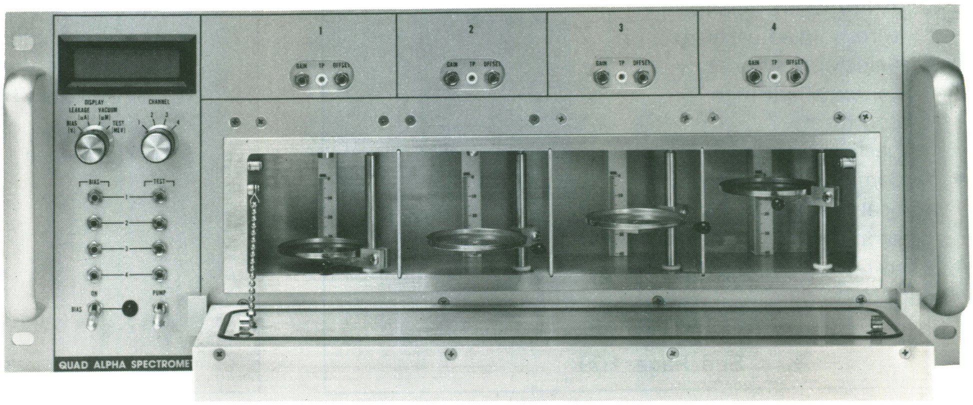
Note: The above configurations are offered as recommended starting points for building analysis systems for specific applications. Additional capabilities, including on-line computer facilities, are available as needed. Please consult the various catalog sections for details.

NEW PRODUCT SUMMARY

Model 7404

Quad Alpha Spectrometer

- Horizontal Sample/ Detector Position
- Biased, Swing-out Sample Holder
- Up to Two Inch Diameter Sample Size
- Built-in Vacuum Guage
- Digital Detector Bias & Current Metering
- Plug-in Preamp/ Amplifiers
- Vacuum/Bias Safety Interlock

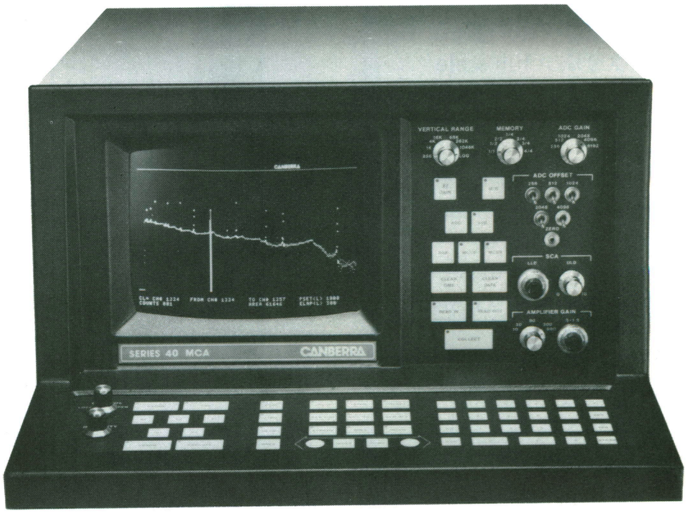

QUAD ALPHA SPECTROMET
1
2
3
4
GAIN
TP
OFFSET
DISPLAY
LEAKAGE
VACUUM
BIAS
TEST
CHANNEL
PUMP

See Page 65

Series 40

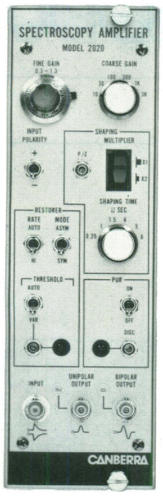
Multichannel Analyzer

- 1024, 4096, or 8192 Channel Memory capacity, 2^{20}-1 counts per channel
- 100 MHz, 8192 Channel ADC with DMA Interface
- 200 KHz or 20 MHz MCS (Option)
- Bipolar Amplifier, Charge or Voltage Input
- Plug-in HVPS or Spectroscopy Amplifier
- Simultaneous Data Acquisition, Display, and I/O
- 9 in. (Diagonal) CRT Linear and Log Display Modes
- Integral, Net Area, Strip, Ratio, and Energy Calibrate for Spectrum Analysis
- Define/Use and Learn/ Execute for Automatic Analysis
- Standard TTY/EIA/ Cassette I/O Interface
- Online Computer Control via RS-232C, RS-422 or IEEE-488 Interfacing


SERIES 40 MCA
CANBERRA
VERTICAL RANGE
MEMORY
ADC GAIN
ADC OFFSET
SCA
AMPLIFIER GAIN

See Page 232

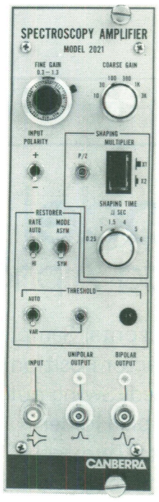
Model 2020
Spectroscopy Amplifier



- 12 front panel selectable shaping time constants
- Noise ⩽3.4μV RMS referred to input at gain ⩾100 and 3μsec shaping
- DC drift ⩽±10μV/°C
- Unique active baseline restorer with:
  1. Automatic or fixed restorer rates
  2. Automatic or manual threshold adjustment
  3. Selectable symmetry for excellent high count rate performance
- Accommodates pulsed optical feedback preamplifiers
- Leading and trailing edge pulse pileup rejection
- Live time correction for pulse pileup and amplifier dead time

See Page 109

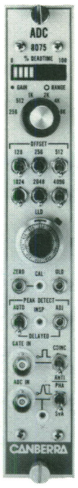
Model 2021
Spectroscopy Amplifier



- 12 front panel selectable shaping time constants
- Noise ⩽3.4μV RMS referred to input at gain ⩾100 and 3μsec shaping
- DC drift ⩽±10μV/°C
- Unique active baseline restorer with:
  1. Automatic or fixed restorer rates
  2. Automatic or manual threshold adjustment
  3. Selectable symmetry for excellent high count rate performance

See Page 113

Model 8075
Analog-to-Digital Converter



- Full 8192 channel conversion gain and range
- Synchronized, crystal controlled 100 MHz clock rate
- Stability better than ±0.009% of full scale/°C
- Pulse pileup rejection input
- Pulse height analysis using either automatic peak detection or delayed triggering
- Analog sampling voltage analysis
- Digital offset in 128 channel increments

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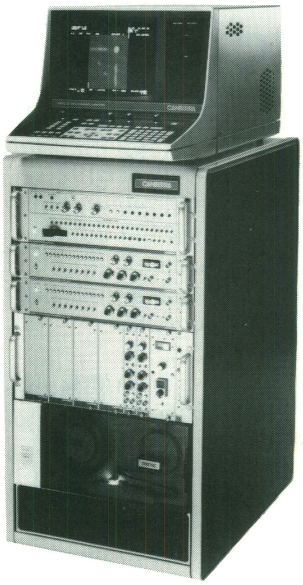
Series 88
Multiparameter System



- 1 to 8 Parameter Data Acquisition via External Canberra ADC's.
- Simultaneous Dual Parameter, PHA, and List Mode Acquisition.
- 8192 or optional 16,384 Data Channels.
- Independent or Dependent ADC Control, with Internal or External Coincidence Logic.
- DMA Data Acquisition Interface, for Maximum Throughput.
- Normal PHA, Isometric, and Contour Display Modes.
- Gross and Net Peak Volume Integration.
- Optional Jupiter Interface for On-line Computer Control.

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DETECTORS 2

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DETECTOR INTRODUCTION

Canberra manufactures a wide range of Germanium Photon Detectors which are described in detail in the following pages.

In addition, we carry many other types of detectors which are compatible with our NIM and MCA products. Some of these detectors are described fully in this section, and limited information is provided for the others. Regardless of whether the particular detector for your application is a Canberra manufactured product or not, we are dedicated to provide complete detector systems for which we take complete systems responsibility.

The following guide illustrates the breadth of the Canberra detector product line:

Type of Radiation			
Charged Particle	**γ-Ray**	**X-Ray**	**Detector Type**
X	X	X	GM Tube, Proportional Counter — For more information on the complete line consult the factory.
X			Low level Alpha/Beta Counting System — complete manual and automatic sample changer systems for low level alpha/beta counting.
	X	X	NaI(Tl) Scintillation Detectors — Standard sizes to 3" x 3" (7.62cm x 7.62cm) Consult factory for sizes not represented, including annuli for Ge(Li) Compton Suppression Systems.
X			Silicon Surface Barrier Detectors — Complete line of detectors including ruggedized types.
	X	X	Planar Pure Ge Detectors — Low Energy Photon Spectrometers for the energy range of 2keV to 200keV.
	X		Coaxial Ge(Li) Detectors — Broad range of detector sizes featuring metal-to-metal seal cryostats.
	X	X	Coaxial Pure Ge Detectors — Consult factory for availability, specifications and prices.
		X	Si(Li) Detectors Systems — for x-ray detection exclusively below 30keV.

Germanium Detectors

Germanium Detectors

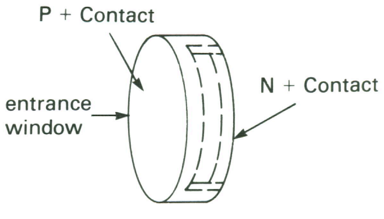
INTRODUCTION

Germanium detectors are semiconductor diodes having a P-I-N structure in which the Intrinsic (I) region is sensitive to ionizing radiation, particularly X-rays and gamma rays. Under reverse bias, an electric field extends across the intrinsic or depleted region. When photons interact with the material within the depleted volume of a detector, charge carriers (holes and electrons) are produced and are swept by the electric field to the P and N electrodes. This charge, which is in proportion to the energy deposited in the detector by the incoming photon, is converted into a voltage pulse by an integral charge sensitive preamplifier.

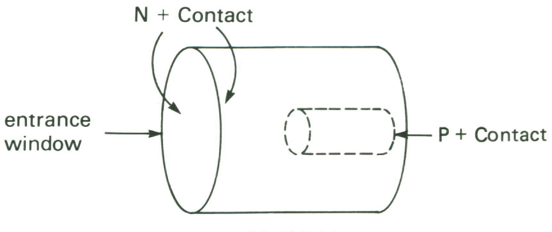
Because germanium has a relatively low energy gap, these detectors must be cooled in order to reduce the thermal generation of charge carriers (thus reverse leakage current) to an acceptable level. Otherwise, leakage current induced noise destroys the energy resolution of the detector. Liquid nitrogen, which has a temperature of 77°K, is the common cooling medium for such detectors. The detector is mounted in a vacuum chamber which is attached to or inserted into an LN_2 dewar. The sensitive detector surfaces are thus protected from moisture and condensible contaminants.

TYPES OF GERMANIUM DETECTORS

There are two common basic geometries among Ge detectors, planar and coaxial, and the latter are available from drifted or from high purity germanium. The illustrations depict the structure of planar and coaxial detectors.



PLANAR



COAXIAL

Planar Ge Detectors

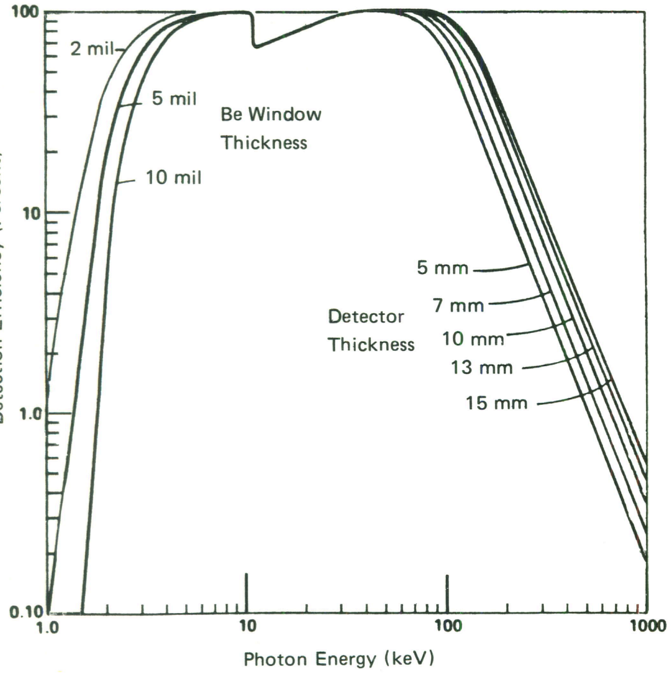
Features

- High Purity Germanium
- Ship and Store w/o LN_2
- Wide Energy Range
- High Resolution
- Choice of Preamplifier Types

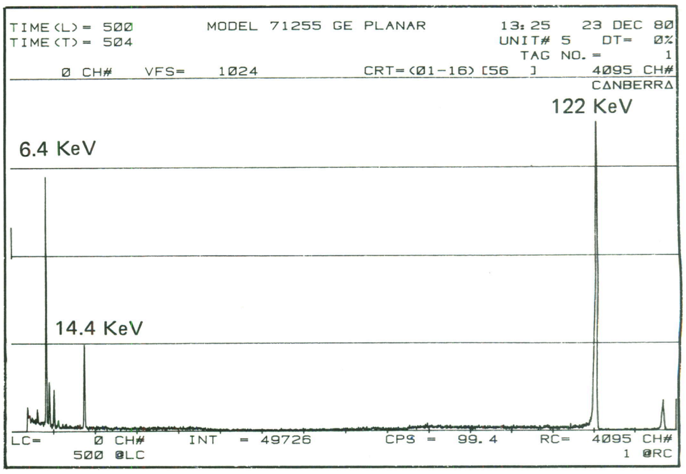
Description

The Planar detector is made from germanium having very low impurity concentration so that with appropriate P and N contacts, the detector can be fully depleted with reasonable bias voltages. The *planar* detector is fabricated from a circular disc of germanium by making a Lithium diffused (N+) contact on one side and a surface barrier or ion implanted contact (P+) on the other. The detector typically is grooved on the rear (N+) contact to reduce leakage current along the surface between the contacts.

The detector is mounted in a cryostat with the thin P+ contact facing the entrance window. The cryostat window is typically made from beryllium for improved sensitivity to low energy photons. This detector is useful down to energies of 3 keV or so, and, depending on thickness, up to several hundred keV. A chart of efficiency vs. energy for detectors and cryostat windows of different thickness is shown below:



Planar Ge Efficiency Curve



```
TIME(L)= 500         MODEL 71255 GE PLANAR         13:25   23 DEC 80
TIME(T)= 504                                       UNIT# 5    DT=  0%
                                                     TAG NO. =      1
     0 CH#   VFS=    1024              CRT=(01-16)[56  ]     4095 CH#
                                                             CANBERRA
```

```
LC=        0 CH#     INT   = 49726         CPS  =   99.4    RC=  4095 CH#
         500 @LC                                                    1 @RC
```

The excellent energy resolution of Canberra's Planar Ge Detectors is shown in this Spectrum of Co-57

PREAMPLIFIERS FOR PLANAR Ge DETECTORS

At low energies, the preamplifier noise becomes the dominant contributor to detector system resolution or spectral line width. For this reason, the planar detector is equipped with a preamplifier having a low noise FET input circuit which is located inside the cryostat and cooled to an optimum temperature (typically around 120°K). In addition, further noise reduction is possible by eliminating the feedback resistor in the first stage of the preamplifier and substituting so-called pulsed optical feedback.

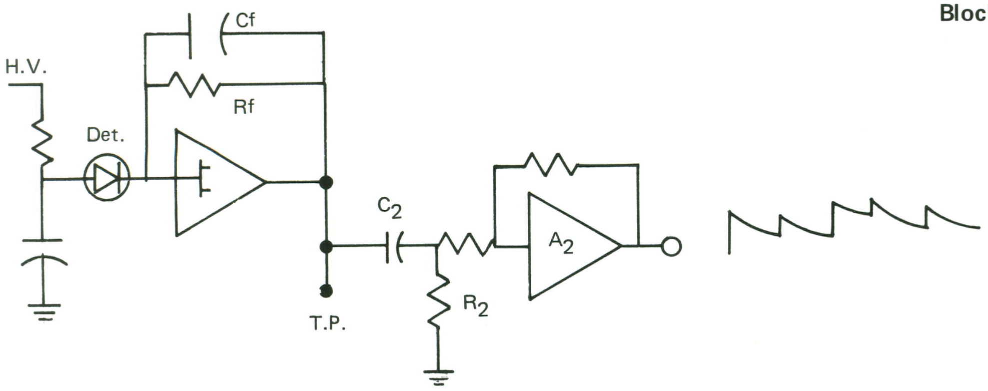
Canberra offers the choice of RC feedback preamplifiers or pulsed-optical preamplifiers on its planar germanium detectors. The Model 2008 pulsed optical type preamplifier affords better resolution at low energies and at low total energy rates. The 2001 RC preamplifier gives better performance at high total energy rates. It is, therefore, used exclusively on larger detectors which have greater stopping power for high energy photons. Block diagrams and descriptions of the operating principles of each type are illustrated:

RC FEEDBACK (DYNAMIC CHARGE RESTORATION)

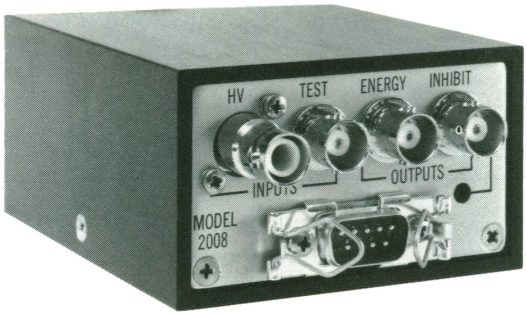
H.V
TIMING
ENERGY
TEST
INPUT
INPUT
MODEL
2001
POWER

MODEL 2001 CP

Charge impulses (Qin) from the detector result in equivalent charge stored on feedback capacitor (Cf) producing step function Vo=Qin/Cf. Rf allows Cf to discharge with time constant 1/RfCf. This signal is differentiated by C_2 - R_2 and amplified by x5 or x10 by amplifier A-2.

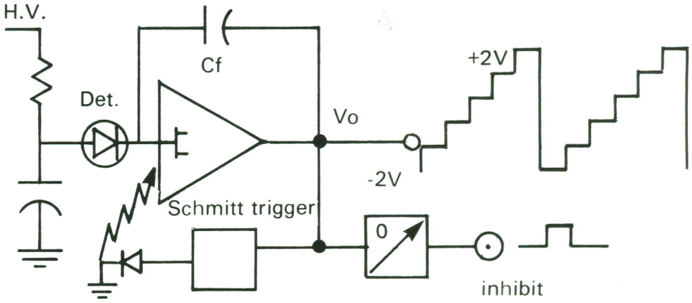


Block Diagram - Model 2001CP



PULSED-OPTICAL FEEDBACK MODEL 2008

Charge impulses (Qin) from the detector result in equivalent charge stored on feedback capacitor Cf producing step function Vo=Qin/Cf. Subsequent impulses increase the output to a limit of +2 volts at which point the schmitt trigger fires an LED directed at the FET. The light pulse momentarily shorts out the FFT gate-source junction thus discharging Cf and resetting the preamplifier to -2 volts. An adjustable width monostable multivibrator provides a pulse which can be used to gate off the MCA during the transient reset time.



Block Diagram - Model 2008

PLANAR GERMANIUM DETECTORS

Planar Germanium Detectors include: Preamplifier, Vertical Dipstick Cryostat with 30 Liter Dewar, Optional Cryostats are available. Consult factory for price and availablity of larger detectors.

System Model Number is detector Model — Cryostat Model; e.g. 71255-7500.

Model #	Detector Dimensions*			Detector Resolution [ev (FWHM)]			Be Window (mils)
	Area (mm^2)	Dia. (mm)	Depth (mm)	at 5.9 keV P.O.†	R.C.††	at 122keV	
71255P	25	5.6	5	145	165	500	2.0
71255	25	5.6	5	155	170	500	2.0
71255E	25	5.6	5	180	200	550	2.0
71505	50	8.0	5	165	180	500	2.0
71505E	50	8.0	5	190	210	520	2.0
711005	100	11.3	5	185	200	520	3.0
711005E	100	11.3	5	220	240	570	3.0
711007	100	11.3	7	175	190	520	3.0
711007E	100	11.3	7	210	230	570	3.0
71100710	100	11.3	10	175	185	520	3.0
7110010E	100	11.3	10	210	240	570	3.0
712005	200	16.0	5	240	260	590	6.0
712005E	200	16.0	5	280	290	590	6.0
712007	200	16.0	7	220	240	540	6.0
712007E	200	16.0	7	270	280	590	6.0
7120010	200	16.0	10	220	240	540	6.0
7120010E	200	16.0	10	280	290	590	6.0
713005	300	19.5	5	300	350	580	6.0
713005E	300	19.5	5	360	400	650	6.0
713007	300	19.5	7	260	300	580	6.0
713007E	300	19.5	7	320	350	650	6.0
7130010	300	19.5	10	250	280	580	6.0
7130010E	300	19.5	10	330	350	650	6.0
715005	500	25.5	5	350	390	600	6.0
715005E	500	25.5	5	420	460	720	6.0
715007	500	25.5	7	320	360	600	6.0
715007E	500	25.5	7	390	430	720	6.0
7150010	500	25.5	10	300	340	600	6.0
7150010E	500	25.5	10	370	400	720	6.0
7110005	1000	35.7	5		500	670	16.0
7110005E	1000	35.7	5		640	850	16.0
7110007	1000	35.7	7		450	640	16.0
7110007E	1000	35.7	7		590	810	16.0
71100010	1000	35.7	10		430	630	16.0
71100010E	1000	35.7	10		590	760	16.0
71100013	1000	35.7	13		420	630	16.0
71100013E	1000	35.7	13		590	770	16.0

*minimum specifications †Pulsed-Optical Preamplifier ††Resistive Feedback

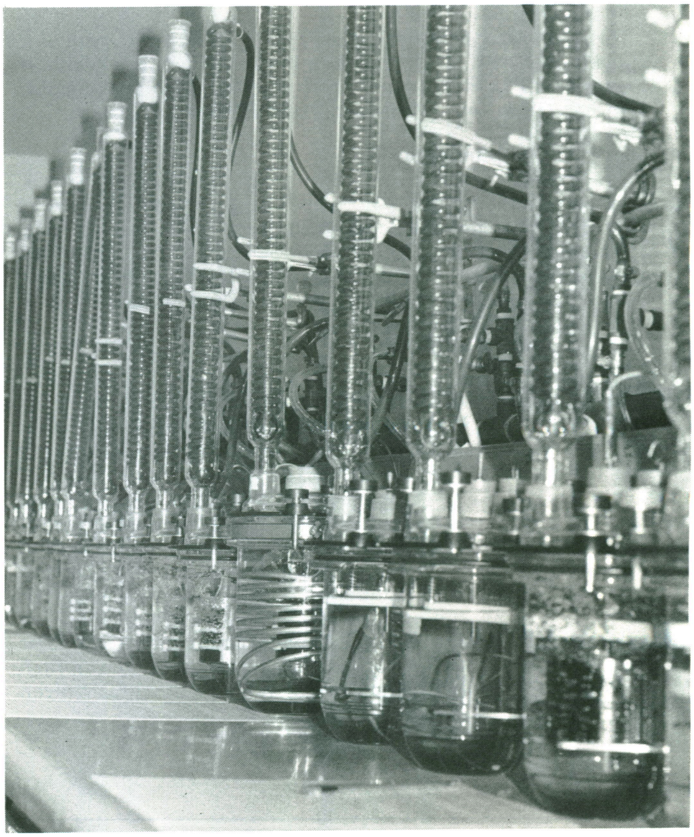
Coaxial Germanium Detectors

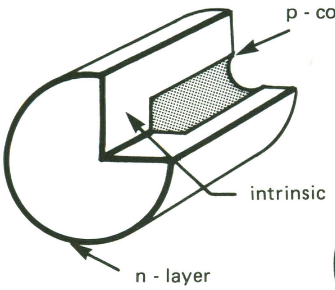
The coaxial detector structure was devised for the following two reasons:

1. It permits the fabrication of large volume and thus high efficiency detectors without requiring extremely deep depletion depths which are difficult to achieve.

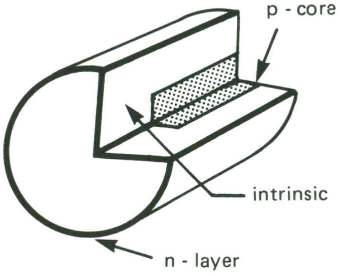
2. It results in a device whose capacitance is not in direct proportion of detector area as in the case of the planar geometry. Since preamplifier noise is a function of the detector capacitance, this results in lower electronics noise contribution.

Most coaxial detectors today are fabricated with the closed-end configuration. This configuration provides a uniformly efficient cross section of active detector volume at the entrance window. The closed-end coax also has a charge collecting N+ contact over the entire window area so there can be no dead layer growth problems.

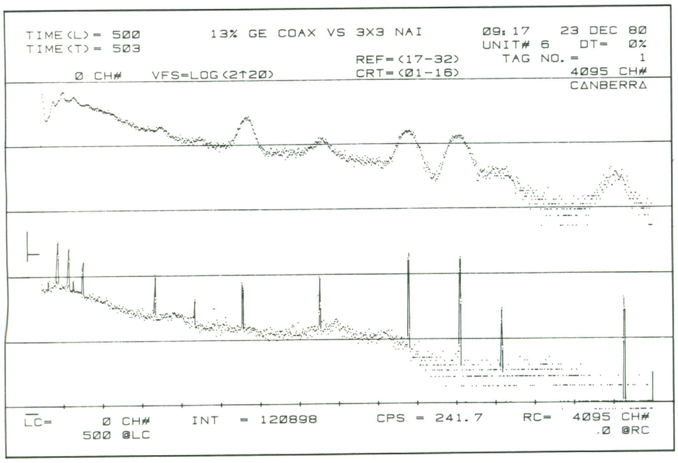




Coaxial HP Ge



Coaxial Ge(Li)



```
TIME(L)= 500        13% GE COAX VS 3X3 NAI          09:17    23 DEC 80
TIME(T)= 503                                        UNIT# 6     DT=  0%
                                     REF=(17-32)     TAG NO. =        1
     0 CH#    VFS=LOG(2↑20)          CRT=(01-16)               4095 CH#
                                                               CANBERRA

LC=       0 CH#     INT   = 120898        CPS  = 241.7      RC=  4095 CH#
        500 @LC                                                   .0 @RC
```

**Comparison of 13% Coaxial Ge Detector and 3 x 3 NaI(TI).
NBS Mixed Point Source.**

COAXIAL Ge AND Ge(Li) DETECTOR SPECIFICATIONS

The performance of Ge detectors is almost always specified for the 1.33 MeV peak of Co-60 which is convenient since Co-60 is a commonly available radioisotope which also has a desirable reference peak at 1.17 MeV for calibration purposes.

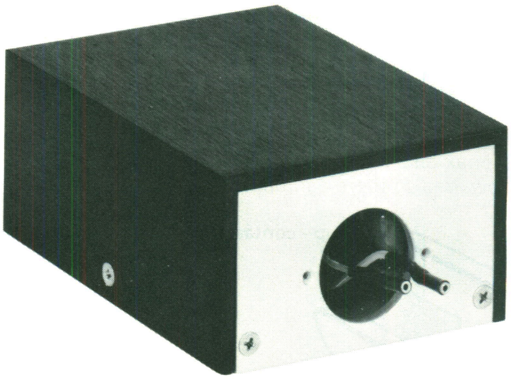
H V
TIMING
ENERGY
TEST
INPUT
MODEL
2001

The salient specifications for Ge detectors are:

1. Relative Efficiency (%)
   This is the full energy peak efficiency for 1.33 MeV photons from an N.B.S. calibrated source located 25cm from the face of the detector divided by 1.2×10^{-3}, which is the absolute efficiency of a 3" x 3" NaI(Tl) detector. It is expressed in percent units.

2. Energy Resolution (keV)
   This parameter is a measure of the "line" or peak width at a given energy. It is expressed in terms of **F**ull peak **W**idth in energy at one-**H**alf or one-**T**enth the **M**aximum peak height. The units are keV (**FWHM**) and keV (**FWTM**).

3. Peak to Compton Ratio (X:1)
   The Peak-to-Compton ratio is defined as the height of the peak divided by the height of corresponding Compton plateau in the region below the edge. In the case of Co-60, the IEEE Standard Test Procedures for Germanium Gamma Ray Detectors. (IEEE Publication No. 321-1971) defines the Compton plateau region to be 1040 to 1096keV. It is expressed as a ratio.



PREAMPLIFIERS FOR COAXIAL Ge DETECTORS

Coaxial detectors are generally used at higher energies and at higher energy rates than their planar counterparts. For this reason the preamplifier characteristics are somewhat different from those used on planar detectors. The feedback resistor and capacitor are chosen to optimize energy rate and resolution and the FET is selected for minimum noise levels with typical coaxial detector capacitance at the input. Good energy resolution is often attainable without cooling the preamplifier front end, although cooled FETs are used when extremely good low energy resolution is required or when the distance between detector and preamplifier (long snout) is greater than 8 inches or so. Performance characteristics for the normal Model 2001 and for the cooled FET version Model 2001 C are given below:

PREAMPLIFIER SPECIFICATIONS AND FEATURES		
	2001	2001C
Noise (Cs=0 pf)	< 600 ev (FWHM)	< 400 ev (FWHM)
Count Rate Capability (Co-60)	> 200 000 cts/sec	> 100 000 cts/sec
Rise Time (Cs-30pf)	< 40 nsec.	< 40 nsec.
Input Coupling	D.C.	D.C.
Outputs	Energy, Timing	Energy, Timing
Leakage Current and Energy/Rate Monitor	Rear Panel Test Point	Rear Panel Test Point
Bias Isolation	± 5000 Vdc	± 5000 Vdc
FET Protection	Diode type	Diode type

Coaxial Ge(Li) Detectors

Features

- Wide Efficiency Range
- High Resolution
- Excellent Peak Shape
- High P/C Ratios
- High Energy Rate Capability
- Room Temp. or Cooled FET

Description

The Coaxial Ge(Li) Detector is fabricated from cylindrical P-type Czochralski grown single crystal germanium by diffusing lithium into the outer surface (except for one end), to form a P-N junction. Then under reverse bias at a temperature of from 25° to 40°C lithium ions migrate toward the center thus compensating for the original P-type impurities leaving a region of net impurities of intrinsic proportions. The resultant device has a P-I-N structure and under conditions of reverse bias photons interacting within the intrinsic or depletion region produce charge carriers which are swept by the electric field to their collecting electrodes. A charge sensitive preamplifier converts this charge to a voltage pulse in proportion to photon energy.

Canberra Ge(Li) detectors are available in a wide range of efficiencies. They are noted for efficiency stability because their closed-end configuration affords a charge collecting surface at the entrance window, so there can be no dead layer growth problems. The high resolution and excellent peak shape both contribute to high Peak-to-Compton ratios.

Generally Canberra Ge(Li) detectors are equipped with a room temperature FET preamplifier which can be serviced or exchanged in the field should the delicate front end components be damaged. For extraordinary resolution, particularly at low energy, a cooled FET preamplifier is used with a standard preamplifier. Canberra Ge(Li) detectors have an energy rate capability of more than 200MeV/sec. —The best in the industry.

DETECTOR MODEL NUMBER DESIGNATION

The following guide may be used in assigning a composite model number to a Ge(Li) detector system.

72 _ 9 - 7_ _ _ - _ _ _ _

Resolution Specifications
e.g. 2.0 keV = 20

Efficiency Specification
e.g. 10% = 10

Cryostat Type
500 = Vertical Dipstick
600 = Horizontal Dipstick
550 = 45° Dipstick
See cryostat section for complete choice.

Detector Geometry
2 = Closed-end Coaxial

e.g. 7229 - 7500 - 1020

This is a closed-end coaxial detector with a vertical dipstick cryostat having 10% efficiency and 2.0 keV (FWHM) resolution.

Ge(Li) Detector Model List

Model Number		Detector Specifications			
		Efficiency (%)	Resolution [KeV(FWHM)] @ 122keV*	@1.33MeV	Peak-to-Compton Ratio @ 1.33MeV
7229-**	-1018	10	0.9	1.8	37
7229-	-1019	10	1.0	1.9	35
7229-	-1020	10	1.0	2.0	33
7229-	-1318	13	0.9	1.8	38
7229-	-1319	13	1.0	1.9	36
7229-	-1320	13	1.0	2.0	34
7229-	-1518	15	0.9	1.8	40
7229-	-1519	15	1.0	1.9	38
7229-	-1520	15	1.0	2.0	36
7229-	-1819	18	1.0	1.9	42
7229-	-1820	18	1.0	2.0	40
7229-	-1821	18	1.1	2.1	38
7229-	-2019	20	1.0	1.9	44
7229-	-2020	20	1.1	2.0	42
7229-	-2021	20	1.1	2.1	40
7229-	-2520	25	1.0	2.0	46
7229-	-2521	25	1.1	2.1	44
7229-	-3020	30	1.1	2.0	48
7229-	-3021	30	1.1	2.1	46
7229-	-3520	35	1.1	2.0	50
7229-	-3521	35	1.2	2.1	48
7229-	-4020	40	1.1	2.0	52
7229-	-4021	40	1.2	2.1	50

*Typical Results, Actual Performance may vary depending on whether room temp. FET is used, etc.
**Insert cryostat model number here.

Thin Window Ge(Li) Detectors

Features

- Good Low Energy Response
- Wide Efficiency Range
- Excellent Peak Shape
- High P/C Ratios
- High Energy Rate Capability
- Room Temp. or Cooled FET

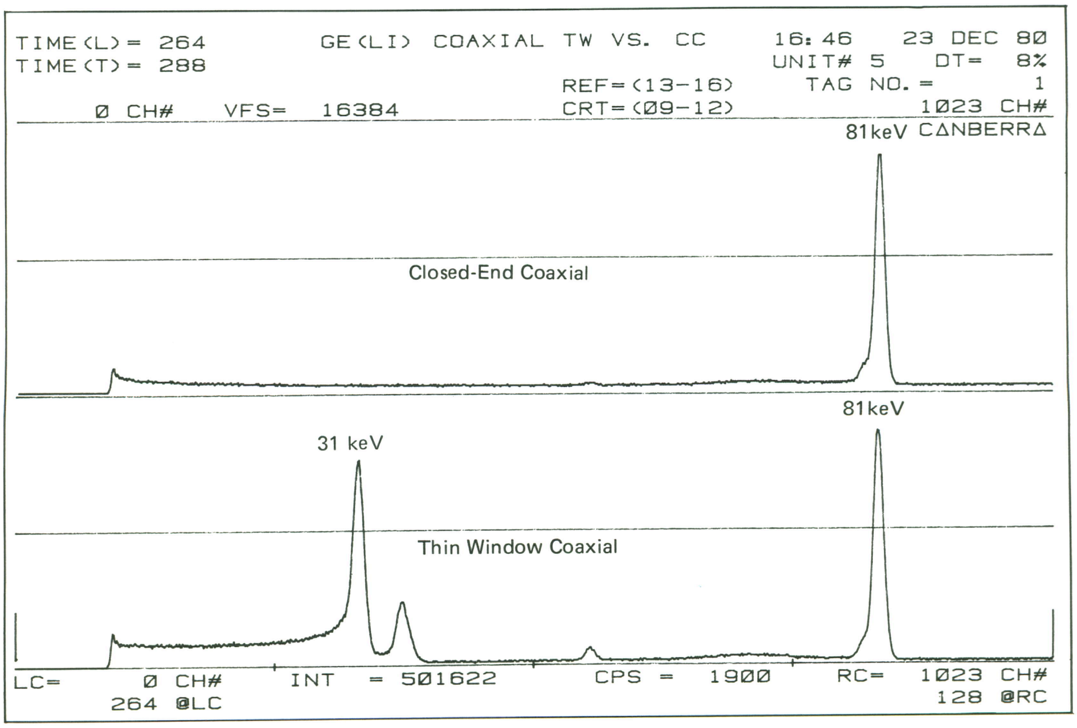
Description

The conventional Ge(Li) detector has a lithium-diffused contact on the outer surface window of about 0.5mm thickness. This dead layer is sufficient to stop more than 50% of 50KeV photons and renders the detector virtually worthless below 30KeV.

Canberra has now developed a technique for reducing the dead layer thickness at the entrance window to approximately 100 microns, thus extending the useful energy range of the detector to 20KeV and below.

This low energy performance advantage is illustrated by the spectra below comparing a conventional Ge(Li) to a thin-window Ge(Li) in the detection of Ba^{-133}

The Thin Window Ge(Li) is available in the same wide range of sizes and performance as our conventional Ge(Li) detectors.



Coaxial Ge Detectors

Features

- Ship and Store without LN_2
- Room Temp. or Cooled FET
- High Resolution
- Excellent Peak Shape
- Wide Efficiency Range
- High Peak-to-Compton Ratios
- Portable Cryostats Available

Description

The conventional coaxial germanium detector is often refered to as Pure Ge. HPGe, Intrinsic Ge, or Hyperpure Ge. Regardless of the superlative used, the detector is basically a cylinder of germanium with an n-type contact on the outer surface, and a p-type contact on the surface of an axial well. The germanium has a net impurity level of around 10^{10} atoms/cc so that with moderate reverse bias, the entire volume between the electrodes is depleted. and an electric field extends across this active region. Photon interaction within this region produces charge carriers which are swept by the electric field to their collecting electrodes where a charge sensitive preamplifier converts this charge into a voltage pulse proportional to the energy deposited in the detector.

The n and p contacts or electrodes are typically diffused lithium and gold surface barriers respectively. The outer n-type diffused lithium contact is about 0.5 mm thick. The inner surface barrier contact is about 40 Mg/cm^2 of evaporated gold. Ion Implanted Boron may be substituted for the surface barrier contact with equal results.

The Canberra Coaxial Ge detector can be shipped and stored without cooling. Like all germanium detectors, however, it must be cooled when it is used to avoid excessive thermally generated leakage current. The non-perishable nature of this detector widens the application of Ge spectrometers to include field use of portable spectrometers.

The useful energy range of the Coaxial Ge detector is 50 keV to more than 10 MeV. The resolution and peak shaper are comparable to the best Ge(Li) detector and they are available over a wide range of efficiencies. A list of available models is given on the next page. Consult the factory or your local Canberra representative for availability of other sizes.

Coaxial Ge Detector Model List

Model No.		**Detector Performance Specifications**			
		Efficiency (%)	**Resolution [KeV(FWHM)]**		**Peak to Compton Ratio**
			at 122keV*	**at 1.33MeV**	**at 1.33MeV**
7229P- **	-518	5	0.8	1.8	26
7229P-	-519	5	0.9	1.9	24
7229P-	-520	5	1.0	2.0	22
7229P-	-818	8	0.8	1.8	33
7229P-	-819	8	0.9	1.9	31
7229P-	-820	8	1.0	2.0	29
7229P-	-1018	10	0.8	1.8	37
7229P-	-1019	10	0.9	1.9	35
7229P-	-1020	10	1.0	2.0	33
7229P-	-1021	10	1.1	2.1	31
7229P-	-1319	13	0.9	1.9	38
7229P-	-1320	13	1.0	2.0	36
7229P-	-1321	13	1.1	2.1	34
7229P-	-1519	15	0.9	1.9	40
7229P-	-1520	15	1.0	2.0	38
7229P-	-1521	15	1.1	2.1	36
7229P-	-1819	18	0.9	1.9	42
7229P-	-1820	18	1.0	2.0	40
7229P-	-1821	18	1.1	2.1	38
7229P-	-2019	20	0.9	1.9	44
7229P-	-2020	20	1.0	2.0	42
7229P-	-2021	20	1.1	2.1	40
7229P-	-2520	25	1.1	2.0	46
7229P-	-2521	25	1.2	2.1	44
7229P-	-2522	25	1.3	2.2	42
7229P-	-3020	30	1.1	2.0	48
7229P-	-3021	30	1.2	2.1	46
7229P-	-3022	30	1.3	2.2	44

*Typical results. Actual performance may vary depending on whether room temperature or FET preamp is used, etc.

**Insert Cryostat Model here, e.g. 7500 for vertical dipstick.

Reverse-Electrode Coaxial Ge Detectors

Features

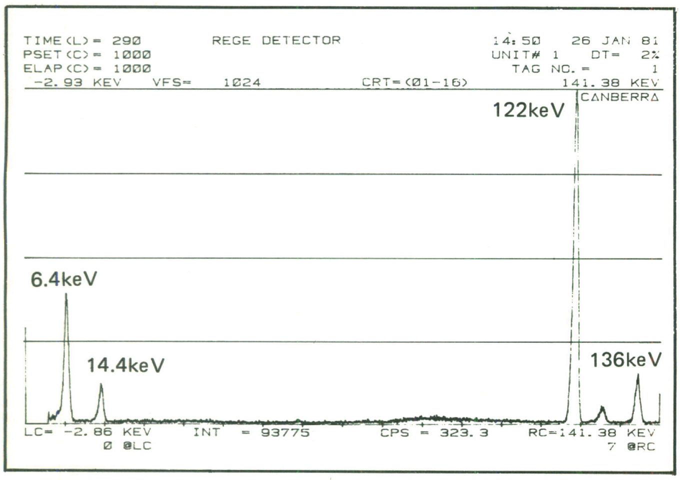
- Thin Window for Low Energy Response
- Radiation Damage Resistant
- Ship & Store w/o LN_2
- Room Temp on Cooled FET
- High Resolution

Description

The Reverse-Electrode Ge detector (REGe) is similar in geometry to other coaxial germanium detectors with one important difference. The electrodes of the REGe are opposite from the conventional coaxial detector in that the p-type electrode, (ion-implanted Boron) is on the outside, and the n-type contact (diffused Lithium) is on the inside. There are two advantages to this electrode arrangement—, window thickness and radiation damage resistance.

The ion-implanted outside contact is extremely thin compared to a lithium-diffused contact. This, in conjunction with a thin cryostat window, extends the energy response down to about 10 keV, giving this detector a dynamic range of 1000:1. Needless to say, this dynamic range exceeds the 100:1 offered by most analysis systems so the detector is unlikely to be covering the range of 10 keV to 10 MeV at once. A spectrum from Co-57 showing the excellent response is shown below.

The radiation damage resistance properties of the REGe detector come about for the following reason. It has been found that radiation damage, principally due to neutrons or charged particles, causes hole trapping in germanium. Unlike the case of the conventional coaxial detector, holes are collected by the outside electrode of the REGe detector. Since a much greater amount of the active detector volume is situated within a given distance, Δ R, of the outside contact, than of the inside contact (Volume $\simeq R^2$) it follows that, on average, holes have less distance to travel if they are attracted to the outside contact than if they are attracted to the inside contact. With less distance to travel, they are less likely to be trapped in radiation damaged material. The extent of the improved resistance to radiation damage depends on other factors, of course, but experimental evidence suggests that the REGe detector may be 10 times as resistant to damage as conventional Coaxial Ge detectors.



```
TIME(L)= 290          REGE DETECTOR               14:50    26 JAN 81
PSET(C)= 1000                                     UNIT# 1    DT=   2%
ELAP(C)= 1000                                       TAG NO. =       1
 -2.93 KEV   VFS=   1024            CRT=(01-16)          141.38 KEV
```

```
LC= -2.86 KEV    INT   = 93775          CPS  = 323.3      RC=141.38 KEV
          0 @LC                                                 7 @RC
```

Co^{57} spectrum with Reverse-Electrode Ge (REGE) Detector equipped with Beryllium entrance window.

The REGe detector is made from Germanium whose residual impurity is N-type rather than P-type. Availability of these detectors is subject to availability of suitable material. Consult the factory or your Canberra representative for up to date availability and pricing information.

Cryostats

CANBERRA CRYOSTATS LAST LONGER!

The liquid nitrogen cryostat is the most important, and least appreciated, component in assuring reliable long term performance of a Ge detector system. Canberra Industries manufactures cryostats to exacting quality standards to ensure long detector life under the most harsh operating conditions.

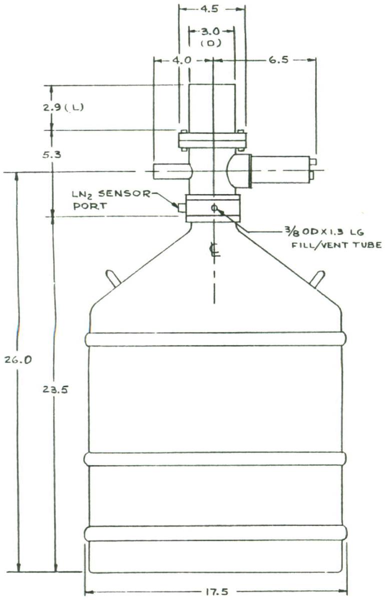
All standard dipstick cryostats use metal-to-metal seals for ruggedness and long term reliability. Less expensive organic "O" rings tend to dry out and leak with age or fail due to contact with liquid nitrogen.

Canberra employs rugged ceramic feedthroughs, welded directly to the vacuum chamber for electrical connection between detector and preamplifier. Less expensive glass feedthroughs are more hygroscopic and more susceptible to mechanical damage.

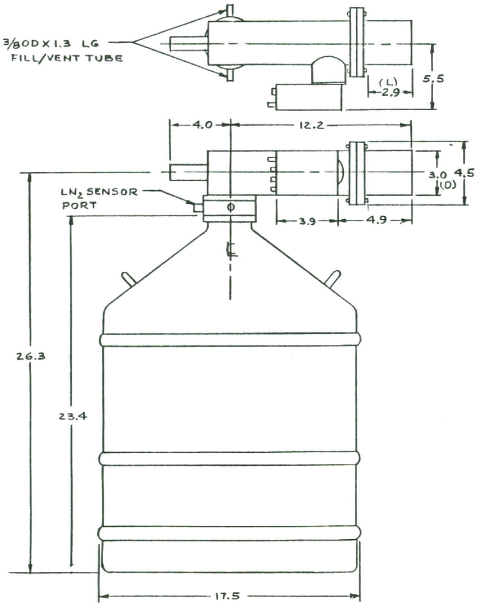
There are two basic types of cryostats in use: the dipstick, in which the detector occupies a vacuum chamber having a dipstick-like tail which is inserted into the neck tube of a dewar, and the integral, in which the detector chamber is permanently attached to the dewar. In the latter case, the detector and dewar may or may not share a common vacuum.

Canberra offers a wide variety of cryostat options many of which are illustrated on the following page.

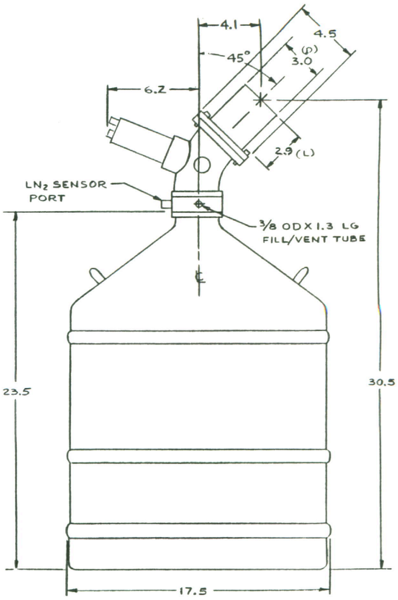
Cryostat Type	Model	Ge(Li)	Ge
Vert. Dipstick	7500	X	X
Horizontal Dipstick	7600	X	X
45⁰ Dipstick	7550	X	X
Horizontal Integral	7905-7.5		X
Horizontal Integral	7905-15		X
Horizontal Integral	7905-30	X	X
Vertical Integral	7906-7.5		X
Vertical Integral	7906-15		X
Vertical Integral	7906-30	X	X
U-Type Integral	7915-30	X	X
Swing-Arm Integral	7925-SA		X
Slim-Line Option		X	X
MAC Portable			X


4.5
3.0
(D)
4.0
6.5
2.9 (L)
5.3
LN₂ SENSOR PORT
⅜ OD X 1.3 LG FILL/VENT TUBE
℄
26.0
23.5
17.5

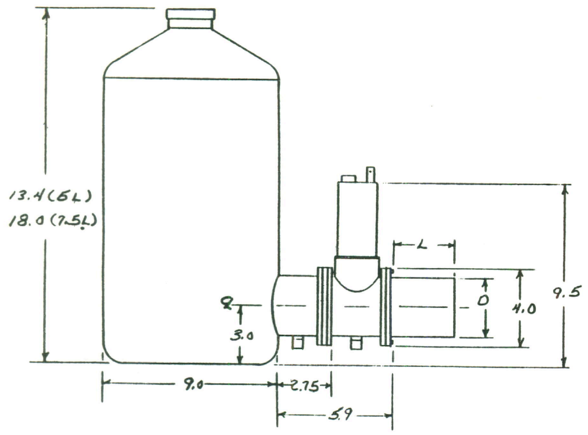
7500 Vertical Dipstick


⅜ OD X 1.3 LG FILL/VENT TUBE
(L)
2.9
5.5
4.0
12.2
LN₂ SENSOR PORT
3.0
(D)
4.5
3.9
4.9
℄
26.3
23.4
17.5

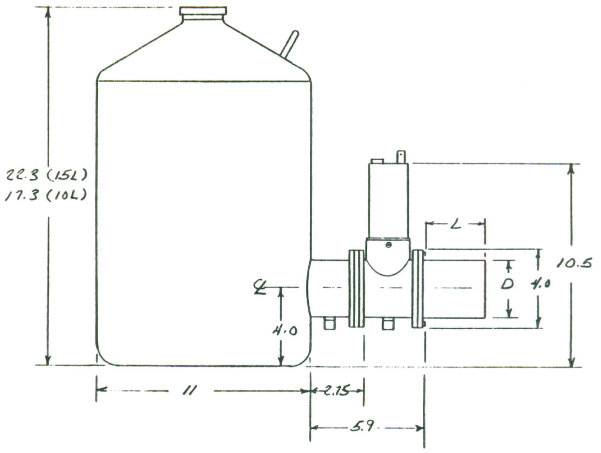
7600 Horizontal Dipstick


4.1
4.5
45°
(D)
3.0
6.2
2.9 (L)
LN₂ SENSOR PORT
⅜ OD X 1.3 LG FILL/VENT TUBE
℄
23.5
30.5
17.5

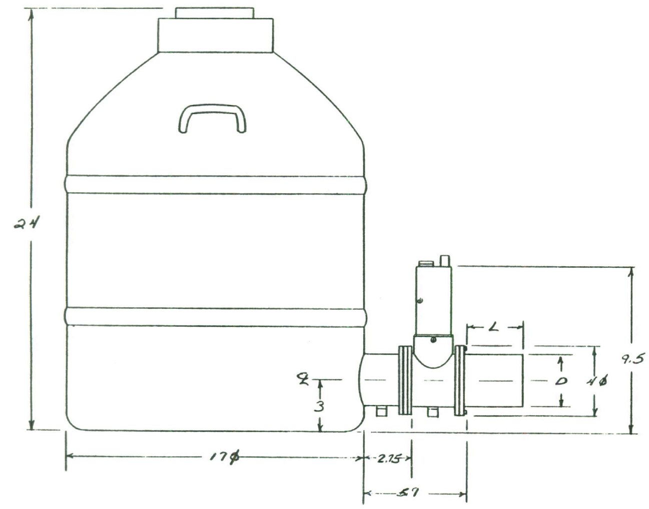
7550 45° Dipstick


13.4 (5L)
18.0 (7.5L)
L
D
4.0
9.5
℄
3.0
9.0
2.75
5.9

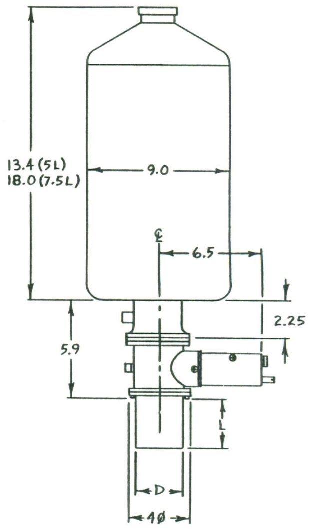
7905D-7.5
7905E-7.5* Horizontal Integral


22.3 (15L)
17.3 (10L)
L
10.5
D
4.0
℄
4.0
11
2.15
5.9

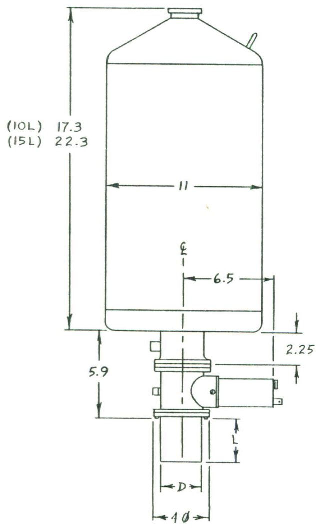
7905D-15
7905E-15* Horizontal Integral


24
L
9.5
℄
3
D
4.0
17.0
2.25
5.9

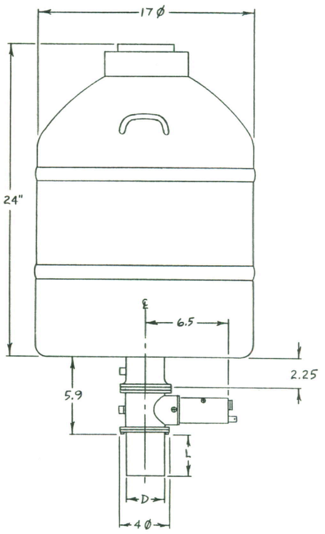
7905D-30
7905E-30* Horizontal Integral


13.4 (5L)
18.0 (7.5L)
9.0
℄
6.5
2.25
5.9
L
D
4.0

7906D-7.5
7906E-7.5* Vertical Integral

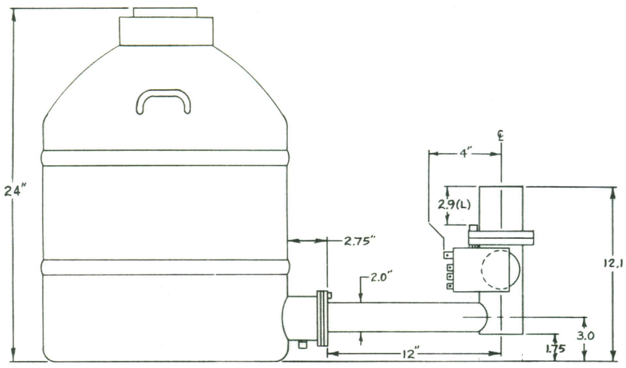

(10L) 17.3
(15L) 22.3
11
℄
6.5
2.25
5.9
L
D
4.0

7906D-15
7906E-30* Vertical Integral

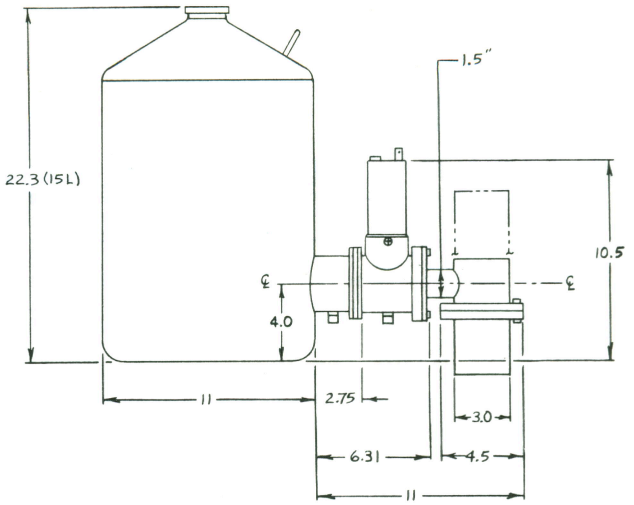

17.0
24"
℄
6.5
2.25
5.9
L
D
4.0

7906D-30
7906E-30* Vertical Integral

***E versions - Dimensions from dewar to end cap flange are reduced by 0.25 inches.**
- Used with Ge (Li) Detectors only.


24"
2.75"
2.0"
4"
℄
2.9(L)
12.1
3.0
1.75
12"

7915D-30
7915E-30* U-Type Integral


22.3 (15L)
1.5"
10.5
℄
4.0
℄
11
2.75
3.0
6.31
4.5
11

7905D-15SA
7905E-15SA* Swing Arm Integral

The detector chamber rotates 180 about horizontal axis.

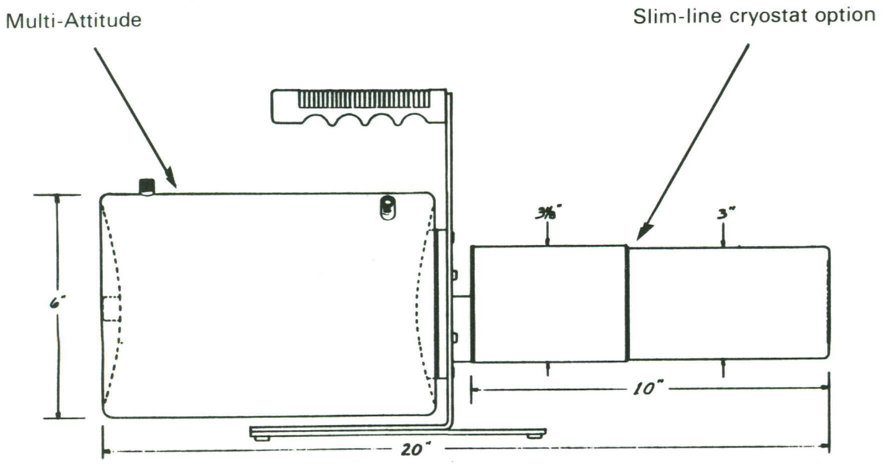
MAC Spectrometer

For applications requiring both portability and flexibility of use, Canberra has developed the Multi-Attitude Cryostat (MAC) which can be operated in any orientation. This unit has an LN2 capacity of 1.5 liters and a holding time of 16 to 24 hours depending on detector size, etc. It is illustrated below with our Slim-line cryostat option.

Slim-Line Cryostat Option

Most Canberra detectors can be provided in our optional Slim-line cryostat which has a very compact geometry. The entire detector chamber/preamplifier assembly is only 80mm (3 1/8 inches) in diameter, which allows it to be shielded with minimum shield volume and weight.

The Slim-line Cryostat option is illustrated below in a portable cryostat configuration:


Multi-Attitude
Slim-line cryostat option
3⅛"
3"
6"
10"
20"

Silicon(Li) X-Ray Detector Systems

The finest in solid state detector technology combined with the most advanced spectroscopy electronics give these solid-state X-ray detector systems solid performance and reliability.

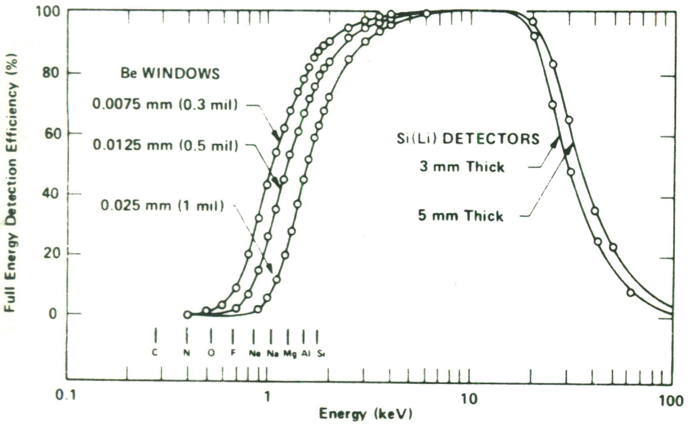
These Si(Li) detectors are available in various sizes as shown on the following page. The resolution is a function of energy and detector area among other things and the efficiency is a function of detector thickness and window thickness as can be seen from the charts below.

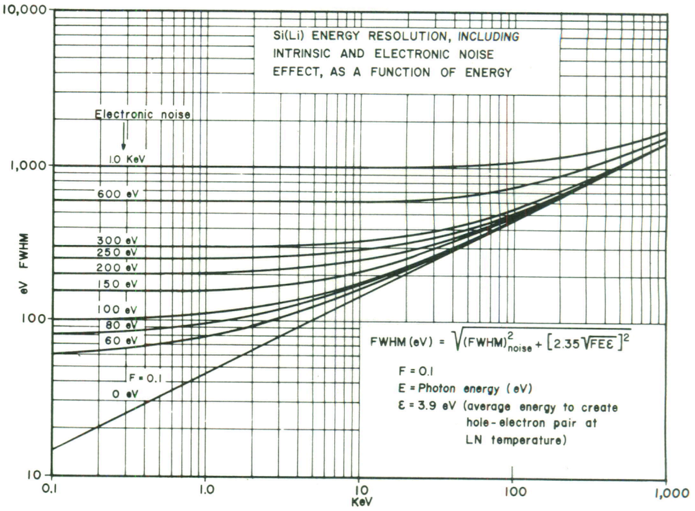
Canberra's leadership in electronics is evident in the system of spectroscopy instrumentation developed to complement the solid state X-ray detector. The crucial preamplifier stage is based on the clearly superior pulsed optical feedback technique and employs a specially fabricated FET, cooled in an integral assembly with the detector in the cryostat.

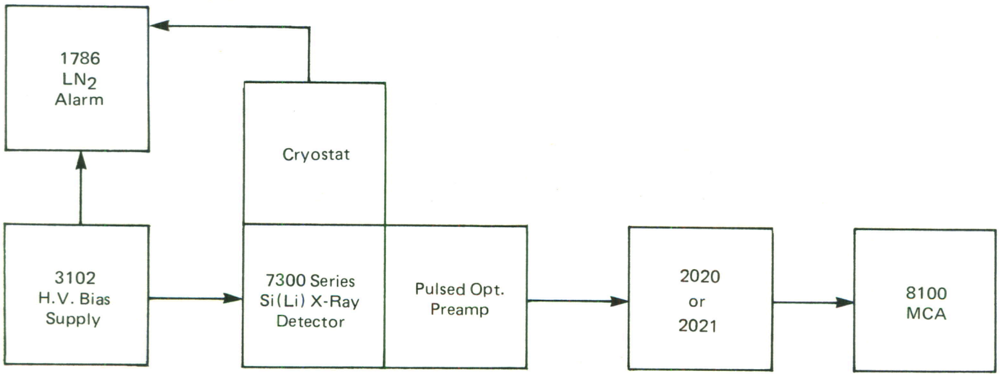
To insure the ultimate in system resolution, the multi time constant main amplifier employs active Gaussian filters and a new gated symmetrical baseline restorer to minimize both high and low frequency noise in the spectrum.

The 2021 Amplifier/Pile-up Rejector incorporates a fast, highly sensitive rejector with a truly accurate live time corrector to maintain the resolution of the system at all count rates and provide data suitable for quantitative corrections. Convenient push-button set-up optimizes the performance of the system.

The Model 1786 LN_2 Monitor protects the detector and front end electronics from damage due to warm-up. Both audible and visual alarms notify the user of a problem and automatic bias shut-down occurs after 30 minutes, should conditions persist.







Si(Li) Detectors

Features

- High resolution
- Long-term reliability

Description

Silicon(Li) X-Ray detectors are the heart of solid state X-Ray spectroscopy systems. These devices, which are p-i-n devices formed by lithium compensation or drifting of p-type silicon, are the result of some of the most carefully controlled manufacturing processes in existence. These detectors are fabricated to exacting quality standards, which are essential in ensuring a product of high performance and excellent long term reliability.

Model	Area (mm^2)	Depth (mm) (nominal)	Resolution* at 5.9keV
7313	10	2	165eV(FWHM)
7333	30	3	170eV(FWHM)
7383	80	5	180eV(FWHM)

*Typical maximum specifications. Consult factory for availability of units with better specifications. FWTM is less than 2 times FWHM.

Specifications

The Silicon(Li) X-Ray detector is an integral part of a detector system which includes a liquid nitrogen cryostat and a low noise preamplifier. For these reasons, the detector performance is not specified independently, but as system performance reflecting the contributions of the electronics and cryogenics. The standard window thickness is 1 mil (25 micron) Be.

CRYOSTAT SPECIFICATIONS

Model	Description	Capacity
7901S	Horizontal Integral	7.5 liters
7500S	Vertical Dipstick	17 liters
7600S	Horizontal Dipstick	17 liters

Options:
30 Liter Dewar for Dipstick Cryostats (7500S and 7600S only)
0.5 mil Be window (7313 and 7333 only)

Preamplifier

Features

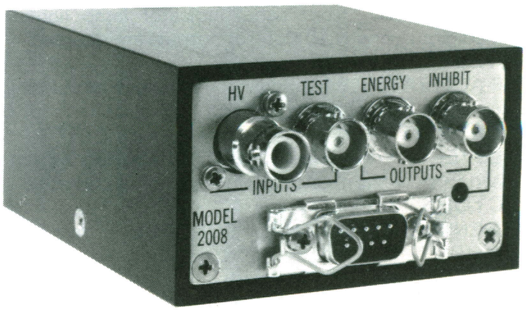
- Pulsed optical feedback for low noise and high count rate performance

Description

The Si(Li) Preamplifier is a cooled input FET charge-sensitive amplifier which employs pulsed optical feedback to enhance the low noise performance required for Canberra high resolution Si(Li) detector systems.

This preamp is normally used with a pulse shaping amplifier such as the Canberra Model 2021. Preamplifier power (±12V, ±24V), detector bias, preamplifier output, and preamplifier reset signals are available through rear panel connectors. A cable is supplied with the preamplifier to connect it with a Canberra Model 2021 Amplifier, which routes power to the preamplifier and accepts the output and reset output signals from the preamplifier for further processing.

This preamplifier is an integral part of a Si(Li) detector system and is neither priced nor sold as a separate component.



Model 1786 Liquid Nitrogen Monitor

Features

- Protection against accidental detector warmup
- Delayed shutdown saves experiments
- Audible, visual and contact closure outputs

Description

The Model 1786 System Alarm protects LN$_2$ cooled detector systems against accidental warmup by monitoring liquid level in the Dewar and providing audible and visual warning of low liquid levels.

The unit has provisions for turning off detector bias when an alarm condition occurs to protect detectors and electronics from damage. Shutdown does not occur until at least 20 minutes after the condition is sensed, in order that ongoing experiments be allowed to continue without interruption.

LN$_2$ MONITOR
1786
H.V. OFF
ACTIVATE
SET UP
LN$_2$ LEVEL
CANBERRA

Specifications

INPUTS

LN$_2$LEVEL INPUT - rear panel BNC connector accepts input signal from remote sensing element which is supplied with the unit

CONTROLLED CIRCUIT - 3-wire line cord input accepts 115-230VAC and routes same through controlled relay to associated controlled instrument such as a Canberra Model 3002 High Voltage Power Supply

OUTPUTS

AUDIBLE - front panel buzzer gives audible warning of alarm condition

VISUAL LN$_2$ LEVEL - front panel indicator light gives warning of alarm condition

CONTROLLED OUTPUT - standard 3-wire 115 volt receptacle provides relay controlled power to associated instrument such as a Canberra Model 3002 High Voltage Power Supply

H.V. CONTROL - contact closure output is grounded during alarm conditions, and is open circuited during normal conditions: provides signal for remote shutdown of Detector Bias Supply

H.V. INDICATOR - front panel indicator lamp lights when the controlled circuit and H.V. Control outputs are disabled

CONTROLS

SETUP-ACTIVATE - front panel toggle switch disables high voltage to allow setup and checkout of alarm circuits without damage to associated electronics

LN$_2$ LEVEL - front panel lighted pushbutton switch which is depressed to clear alarm once alarm situation is corrected

CONNECTORS

LN$_2$ SENSOR INPUT, H.V. CONTROL - rear panel BNC, UG-1094/U

CONTROLLED AC INPUT - 3-wire line cord, 115v power input

CONTROLLED AC OUTPUT - 3-wire standard 115V power output

POWER REQUIREMENTS

+24VDC	— 70mA	+12VDC	— 5mA
- 24VDC	— 0mA	- 12VDC	— 5mA
115VAC	— 60mA		

PHYSICAL

SIZE - standard single-width module (1.35 inches wide) (3.43 cm wide) per TID-20893 (rev.)

NET WEIGHT - 2.2 lbs. (1.0 kg)

SHIPPING WEIGHT - 6.6 lbs. (3.44 kgs)

Silicon Surface Barrier Detectors

Canberra Industries offers a complete line of Silicon Surface Barrier Detectors for charged particle spectroscopy where long term stability, pulse height linearity and negligible dead layer are required.

Both Partially Depleted Detectors (PD Series) and Fully Depleted (FD Series) can be supplied in a wide range of active areas, depletion depths and thicknesses as listed in the tables. The ENVIROGUARD Partially Depleted Detector (Series E) is light-tight and is designed for laboratory or harsh industrial applications.

Each Silicon Surface Barrier Detector is individually tested and the certified test data and measurements are supplied on delivery. All measurement tests are performed and warranted at 22°C.

Total system alpha resolution, FWHM, is warranted using 5.477 MeV alphas from 241 Am. A typical spectrum, for model number PD-25-18-100, is shown in Figure 1. The model number signifies a Partially Depleted Detector with an active area of 25 mm^2, maximum alpha resolution including electronic noise of 18keV FWHM, and depletion depth of 100 microns. Noise width guaranteed maximum FWHM (which approximates beta resolution) is listed in the table for each type detector.

Partially and fully depleted silicon detectors have entrance windows of less than 40μ gm/cm^2 Au; the rear window of the Fully Depleted Detectors is less than 40μ gm/cm^2 Al.

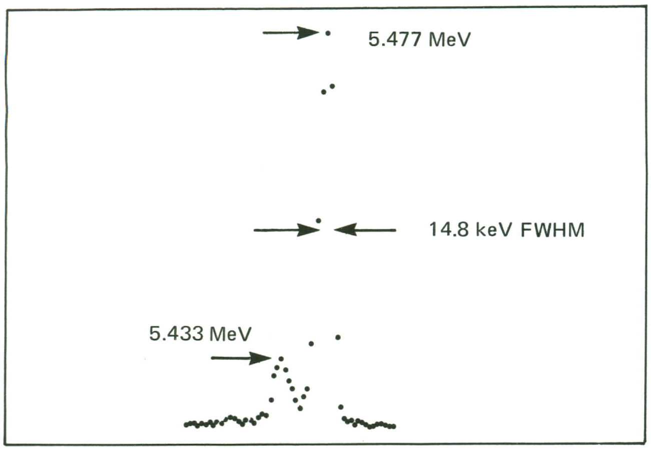


Fig. 1. Am^{241} alpha spectrum. Detector model no. PD-25-18-100

DETECTOR MOUNTING CONFIGURATIONS

Each surface barrier detector is mounted in a stainless steel can. Convenient microdot S-93 connectors are used for both axial and transmission mounts as illustrated in Table A. Fully depleted detectors are normally supplied in stainless steel transmission mount cans with microdot S-93 miniature connectors.

Both partially and fully depleted detectors may be obtained in a ring mount.

Other mounting arrangements or connectors such as BNC style, or other special requirements, may be obtained on request.

INSTRUCTIONS FOR ORDERING SSB DETECTORS

When ordering detectors state detector type, active area, alpha resolution and depletion depth. Each detector model number actually contains the detector specifications. For example, the specifications for model number FD-100-20-500 are:

Detector Type:	Fully Depleted
Active Area:	100 mm^2
Alpha resolution:	20keV FWHM
Depletion depth:	500 microns

*When ordering a Detector, add the appropriate suffix (below) to the end of the model number

R — Ring Mount
T — Microdot Transmission Mount
M — Microdot Axial Mount
B — BNC Axial Mount (Not Available on 25 and 50mm^2 Sizes)

Warranty — Unless otherwise specified, each Silicon Surface Barrier Detector is warranted to operate as specified for a period of one year from date of delivery, provided radiation damage or improper handling has not occurred.

Data Taken from C.F. Williamson, J.P. Boujot and J. Picard, CEA-R-3042 (July 1966)

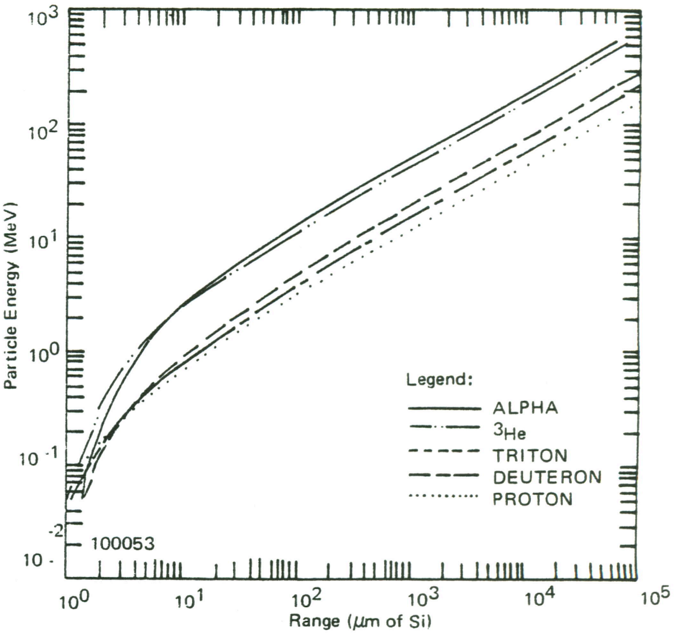
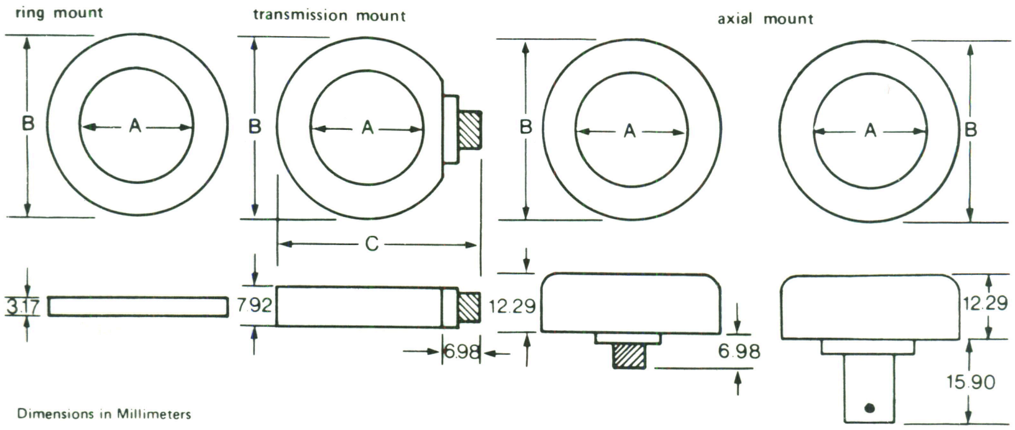


Figure 2. Range-Energy Curves in Silicon

MOUNTING CONFIGURATIONS FOR SURFACE BARRIER DETECTORS



Dimensions in Millimeters

AREA (mm)^2	A	B			C
	all configurations	ring mount	transmission mount	axial mount	transmission mount
25	6.14	14.83	24.79	16.66	30.42
50	8.25	14.83	24.79	16.66	30.42
100	11.73	21.13	31.62	23.41	37.43
150	14.02	21.13	31.62	23.41	37.43
200	16.25	26.59	36.70	28.57	42.57
300	19.81	26.59	36.70	28.57	42.57
450	23.93	29.76	40.00	31.75	45.69

ENVIROGUARD™ PARTIALLY DEPLETED DETECTORS (Series E)

Active Area (mm)^2	Resolution		100μ	300μ	500μ
	α	β	Model No.	Model No.	Model No.
50	19	15	E 50-19-100	E50-19-300	E50-19-500
	23	18	E50-23-100	E50-23-300	E50-23-500
150	21	16	E150-21-100	E150-21-300	E150-21-500
	24	19	E150-24-100	E150-24-300	E150-24-500
300	24	19	E300-24-100	E300-24-300	E300-24-500
	30	25	E300-30-100	E300-30-300	E300-30-500

Specifications:
1. System energy resolution—maximum as stated (keV FWHM).
2. Depletion depth—minimum as stated (microns).
3. Warranty period- one year from date of delivery.

Enviroguard™ Partially Depleted Detectors with an active area of **450mm2** are available on special order only.

PARTIALLY DEPLETED SURFACE BARRIER DETECTORS

Minimum depletion depth for model number

ACTIVE AREA (mm)^2	100 μ			300 μ			500 μ			700 μ			1000 μ		
	Resolution (keV) α	β	Model No.	Resolution (keV) α	β	Model No.	Resolution (keV) α	β	Model No.	Resolution (keV) α	β	Model No.	Resolution (keV) α	β	Model No.
25	15	7	PD-25-15-100	15	7	PD-25-15-300	15	7	PD-25-15-500	16	9	PD-25-16-700	16	9	PD-25-16-1000
	18	12	PD-25-18-100	18	12	PD-25-18-300	18	12	PD-25-18-500	18	12	PD-25-18-700	18	12	PD-25-18-1000
				24	19	PD-25-24-300	24	19	PD-25-24-500	24	19	PD-25-24-700	24	19	PD-25-24-1000
50	15	7	PD-50-15-100	15	7	PD-50-15-300	15	7	PD-50-15-500	16	9	PD-50-16-700	16	9	PD-50-16-1000
	18	12	PD-50-18-100	18	12	PD-50-18-300	18	12	PD-50-18-500	18	12	PD-50-18-700	18	12	PD-50-18-1000
	24	19	PD-50-24-100	24	19	PD-50-24-300	24	19	PD-50-24-500	24	19	PD-50-24-700	24	19	PD-50-24-1000
100	17	11	PD-100-17-100	17	11	PD-100-17-300	17	11	PD-100-17-500	19	13	PD-100-19-700	19	13	PD-100-19-1000
	20	15	PD-100-20-100	20	15	PD-100-20-300	20	15	PD-100-20-500	24	19	PD-100-24-700	24	19	PD-100-24-1000
	24	19	PD-100-24-100	24	19	PD-100-24-300	24	19	PD-100-24-500	30	25	PD-100-30-700	30	25	PD-100-30-1000
150	17	11	PD-150-17-100	17	11	PD-150-17-300	17	11	PD-150-17-500	19	15	PD-150-19-700	19	13	PD-150-19-1000
	24	19	PD-150-24-100	24	19	PD-150-24-300	24	19	PD-150-24-500	24	19	PD-150-24-700	24	19	PD-150-24-1000
	30	25	PD-150-30-100	30	25	PD-150-30-300	30	25	PD-150-30-500	30	25	PD-200-30-700	30	25	PD-150-30-1000
200	20	15	PD-200-20-100	20	15	PD-200-20-300	20	15	PD-200-20-500	21	16	PD-200-21-700	21	16	PD-200-21-1000
	24	19	PD-200-24-100	24	19	PD-200-24-300	24	19	PD-200-24-500	24	19	PD-200-24-700	24	19	PD-200-24-1000
	30	25	PD-200-30-100	30	25	PD-200-30-300	30	25	PD-200-30-500	30	25	PD-200-30-700	30	25	PD-200-30-1000
300	20	15	PD-300-20-100	20	15	PD-300-20-300	20	15	PD-300-20-500	21	16	PD-300-21-700	21	16	PD-300-21-1000
	24	19	PD-300-24-100	24	19	PD-300-24-300	24	19	PD-300-24-500	24	19	PD-300-24-700	24	19	PD-300-24-1000
	30	25	PD-300-30-100	30	25	PD-300-30-300	30	25	PD-300-30-500	30	25	PD-300-30-700	30	25	PD-300-30-1000
450	22	17	PD-450-22-100	22	17	PD-450-22-300	22	17	PD-450-22-500	26	21	PD-450-26-700	26	21	PD-450-26-1000
	26	21	PD-450-26-100	26	21	PD-450-26-300	26	21	PD-450-26-500	30	25	PD-450-30-700	30	25	PD-450-30-1000
	32	27	PD-450-32-100	32	27	PD-450-32-300	32	27	PD-450-32-500	35	30	PD-450-35-700	35	35	PD-450-35-1000

Specifications: 1. System energy resolution—maximum as stated (keV FWHM) 2. Depletion depth—minimum as stated (microns) 3. Entrance window—less than 40μ gms/cm^2 gold 4. Warranty period—one year from date of delivery

Prices F.O.B. Destination.

FULLY DEPLETED SURFACE BARRIER DETECTORS

Minimum depletion depth for model number

ACTIVE AREA mm^2	Maximum System Resolution, keV		150 μ Model No.	200 μ Model No.	Maximum System Resolution, keV		300 μ Model No.	500 μ Model No.
	α	β			α	β		
25	18	9	FD-25-18-150	FD-25-18-200	18	9	FD-25-18-300	FD-25-18-500
50	18	9	FD-50-18-150	FD-50-18-200	18	9	FD-50-18-300	FD-50-18-500
100	18	9	FD-100-18-150	FD-100-18-200	18	9	FD-100-18-300	FD-100-18-500
150	20	13	FD-150-20-150	FD-150-20-200	19	10	FD-150-19-300	FD-150-19-500
200	22	17	FD-200-22-150	FD-200-22-200	20	13	FD-200-20-300	FD-200-20-500
300	23	18	FD-300-23-150	FD-300-23-200	21	17	FD-300-21-300	FD-300-21-500
450	28	21		FD-450-28-200	28	21	FD-450-28-300	FD-450-28-500

ACTIVE AREA mm^2	Maximum System Resolution, keV		1000 μ Model No.
	α	β	
25	19	10	FD-25-19-1000
	24	19	FD-25-24-1000
50	19	10	FD-50-19-1000
	24	19	FD-50-24-1000
100	20	13	FD-100-20-1000
	26	20	FD-100-26-1000
150	20	13	FD-150-20-1000
	27	20	FD-150-27-1000
200	20	13	FD-200-20-1000
	23	18	FD-200-23-1000
	30	25	FD-200-30-1000
300	21	17	FD-300-21-1000
	24	19	FD-300-24-1000
	30	25	FD-300-30-1000
450	28	21	FD-450-28-1000
	30	25	FD-450-30-1000
	35	30	FD-450-35-1000

Specifications: 1. System energy resolution—maximum as stated (keV FWHM) 2. Depletion depth—as stated ± 5% (microns) 3. Entrance window—less than 40μ gms/cm^2 gold front window, less than 40μ gms/cm^2 aluminum back window 4. Warranty period—one year from date of delivery

Prices F.O.B. Destination.

Model 7400A Vacuum Chamber

Features

- Front opening hinged door
- Adjustable sample holder with calibrated scale
- Integral BNC-microdot feedthrough
- Three-way PUMP-OFF-VENT control

Description

The Canberra Model 7400A Vacuum Chamber provides an ideal vacuum environment for Alpha and Beta spectroscopy using silicon surface barrier detectors. The chamber is equipped with a front-opening hinged door so that the sample-detector geometry can be readily and reliably fixed without moving the chamber or parts thereof.

The chamber is equipped with a hermetic BNC (outside) to Microdot S-93 (inside) electrical feedthrough for ready installation of a surface barrier detector and preamplifier. BNC to BNC feedthrough adapters and direct mount preamplifier hardware are available at extra cost.

The chamber has a three-way, PUMP-OFF-VENT valve on the front. The evacuating port is a 3/8" O.D. tube suitable for use with a 1/4" vacuum hose.

The adjustable sample holder has a slotted 1-1/4" wide recess for easy insertion and withdrawal of samples in close proximity to the detector. The sample detector distance is continuously adjustable from 0 to about 8cm. A built-in scale (mm) is provided to facilitate quick and accurate positioning of the sample.

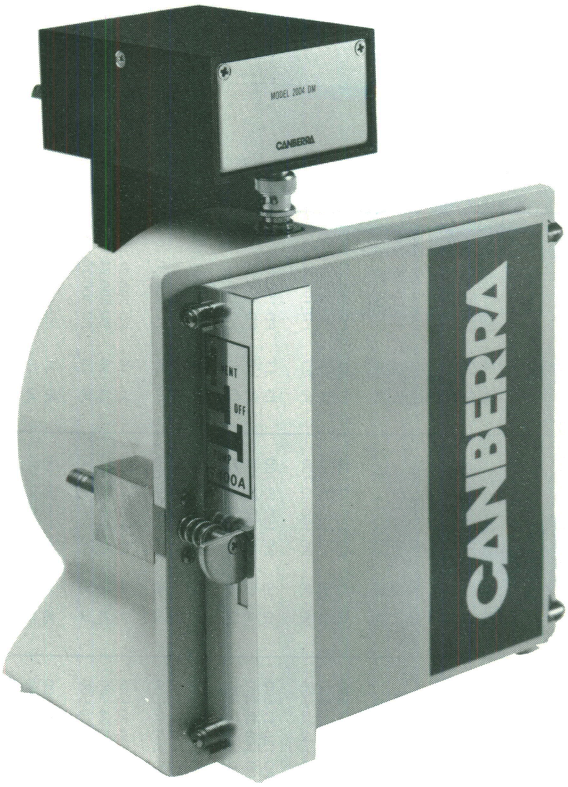


Fig. 1 7400A Shown with Model 2004 DM attached.

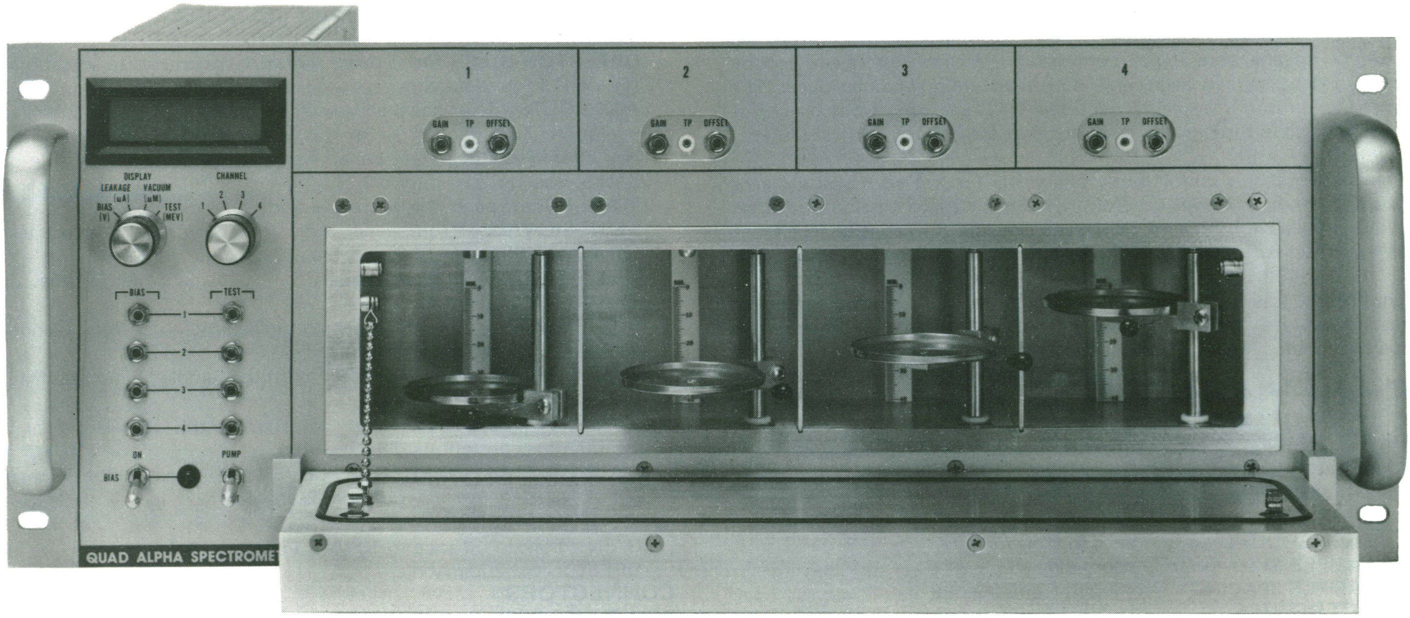
Specifications

OUTSIDE DIMENSIONS - 7" H x 7-1/4" W x 6-1/2" D (17.8cm H x 18.41cm W x 16.5cm D)
INSIDE DIMENSIONS - 5-1/4" Dia. x 4" Deep (13.33cm Dia. x 10.16cm Deep)
PUMP PORT - 0.375 O.D. Tube
VALVE - Three-way (PUMP-OFF-VENT)
ELECTRICAL FEEDTHROUGH CONNECTOR - BNC UG-1094/U (outside) Microdot (S-93) (inside)
NET WEIGHT - 6 lbs. (2.7 kgs)
SHIPPING WEIGHT - 11 lbs. (4.95 kgs)

OPTIONS

7400-06 BNC to BNC electrical feedthrough (Female-Female)
7400-05 Vacuum Hose, 1/4" I.D. x 3/8" wall, (0.64cm I.D. x 0.95cm wall), red rubber
7400-04 Filter (Prevents oil back streaming) (for 1-4 chambers)

Model 7404
Quad Alpha Spectrometer



Features

- Horizontal Sample/Detector Position
- Biased, Swing-out Sample Holder
- Up to Two Inch Diameter Sample Size
- Built-in Vacuum Guage
- Digital Detector Bias & Current Metering
- Plug-in Preamp/Amplifiers
- Vacuum/Bias Safety Interlock

Description

The Canberra Model 7404 is a four-channel Alpha Spectrometer with built-in power supply, vacuum gauge, detector bias supply, test pulse generator, leakage current monitor, and preamplifier/amplifiers. The 7404 is complete. It interfaces directly to an MCA having a mixer-router input without the need for additional instrumentation to complete a four-channel Alpha Spectrometer System. The 7404 offers unequalled performance in terms of counting geometry, ease-of-use, diagnostic capability, maintainability and versatility.

The 7404 is designed for maximum flexibility in sample size and geometry. The sample holder is 2 inches in diameter. It can be readily adjusted for 0 to 30mm detector-sample spacing. Spacers are available for a wide variety of sample diameters up to 2 inches. The sample holder itself can be biased with a d.c. voltage of 0 to -12 volts to help prevent detector contamination due to recoil. In addition, the sample holder swings out toward the operator for ease of loading samples. It is locked in position beneath the detector when the chamber door is closed to start a counting cycle. The sample holder is fabricated from stainless steel for low background contribution.

A built-in power supply provides ± 12 Vdc and ± 24 Vdc power for the internal electronics and for the Model 7404-01 preamplifier/amplifier modules which process signals from the detectors. It also provides 0 to -12 Vdc (internally adjustable) bias for the sample holders to help prevent detector contamination due to recoil.

A low noise, four channel, 0 to ± 200 volt d.c. power supply is provided for detector bias. The bias voltage for each of the four detectors is independently adjustable by means of front panel screwdriver controls. The bias voltage is monitored by a built-in 3½ digit panel meter. Polarity of the bias voltage is internally selectable. The bias supply is interlocked to the vacuum gauge to ensure that bias is not applied during poor vacuum conditions. Bias is disabled when the pressure inside the chamber is above an internally preset level. A front panel indicator tells the operator when the preset pressure level is reached and bias is applied.

The detector bias rises with an internally selected time constant of 1 to 5 minutes. In case of power failure, or vacuum system malfunction, bias voltage is reduced quickly to avoid possible damage to the detectors due to microplasma breakdown.

The 7404 provides a means for measuring detector leakage current using the built-in 3½ digit panel meter. This exclusive feature allows the user to diagnose detectors and to optimize the performance of detectors in a way never before possible. By measuring their V-I characteristics, the user can select the optimum operating voltage—thereby improving system performance and/or extending the useful life of detectors.

The vacuum chamber of the 7404 is equipped with a thermocouple vacuum gauge tube which is read-out by the digital panel meter. This provides the user with a ready means of determining vacuum conditions within the detector chamber. The vacuum gauge is interlocked to the detector bias circuit to prevent application of bias while vacuum conditions are poor.

The 7404 in conjunction with its complementary 7404-01 Preamplifier/Amplifier provides independently controlled **calibrated** test signals which can be used to calibrate the detector system **without** the use of alpha sources. In the test mode, the panel meter displays test signal energy for each of the four channels. By means of front panel and offset controls on the Preamplifier/Amplifier, each channel can be calibrated to the exact energy range desired.

The 7404 vacuum chamber is helium leak tested to 10^{-10} std. cc/sec. The chamber door is equipped with precision hinges which automatically adjust for O-ring compression and hardware tolerances. Vacuum is controlled by means of a stainless steel, three-way, solenoid valve

Description (continued)

which is interlocked to the bias network and vacuum monitor to prevent accidental damage to detectors. The chamber may be vented to and purged by an inert gas during sample changes to prevent introduction of contaminants such as radon during sample changes.

The 7404 is equipped with a special filter to prevent backstreaming of vacuum pump oil into the detector chamber.

The model 7404-01 Preamplifier/Amplifier provides signal conditioning and amplification which is optimal for the type of detectors used in Alpha Spectroscopy. It accepts power, bias and test signals from the 7404 by means of a 9 pin connector. Bias and test signals can be monitored as applied also via BNC connectors on the rear panel. The amplifier output is available on a rear BNC and on a front panel test point accessible through the front panel of the 7404.

The gain control is continuously adjustable for X 1 to X2.5 by means of a 22 turn screwdriver control on the front panel. The output offset is also adjustable by means of a front panel 22 turn control. The range of d.c. offset is ± 200 mVdc. The sensitivity is 1 volt/MeV.

The 7404-01 is a plug-in module which can be removed for bench testing and ready replacement in the field. Critical spares of this sensitive system component are off the shelf.

Specifications

PERFORMANCE SYSTEM (Based on use of PD-450-26-100M Detector)

- **ENERGY RESOLUTION** - ⩽ 26 keV (FWHM)
- **EFFICIENCY** - ⩾25%
- **BACKGROUND** - ⩽ 1 count/Hr. above 3 MeV
- **SAMPLE SIZE** - up to 2 inches diameter
- **SAMPLE SPACING** - 1 to 30mm from detector

ELECTRONICS

BIAS SUPPLY

- **RANGE** - 0 ± 199.9 Volts
- **STABILITY** - ⩽ 50 ppm/°C
- **NOISE** - ⩽ 5 mv Peak-to Peak
- **DISPLAY RESOLUTION** - 0.1 volt

CALIBRATION PULSER

- **STABILITY** - ⩽ 50 ppm/°C
- **RANGE** - 0 - 19.99 MeV
- **DISPLAY RESOLUTION** - 10 keV

DETECTOR CURRENT MONITOR

- **RANGE** - 0 - 19.99μA
- **DISPLAY RESOLUTION** - 0.1μA

SAMPLE BIAS SUPPLY

- **RANGE** - 0 to -12 Volts DC (internally adjustable)

VACUUM GAUGE

- **RANGE** - 0 - 1000 microns (standard)
  - 0 - 19.99 torr (optional)

Conversion chart provided for meter reading to pressure level at extremes of scale.

PREAMPLIFIER/AMPLIFIER (Model 7404-01)

- **SHAPING** - 1μsec unipole, d.c. restored
- **NON-LINEARITY** - ⩽0.1% of full scale
- **Output** - 0 to 10 volts, positive

CONTROLS

- **DISPLAY SELECT** - Front panel rotary switch selects function displayed: Bias, Leakage Vacuum or Test Energy.
- **CHANNEL SELECT** - Front panel rotary switch selects channel displayed.
- **DETECTOR BIAS** - Front panel screwdriver controls to adjust bias for each of four detectors.
- **A.C. VOLTS** - Rear panel slide switch to select 115 Vac or 230 Vac operation.
- **H.V. INTERLOCK** - Rear panel locking toggle switch to enable or disable Vacuum/Bias interlock.
- **POWER** - Rear panel toggle enables or disables main power.
- **TEST SIGNAL** - Front panel screwdriver controls to adjust test signal energy for each of four channels.
- **DETECTOR BIAS** - Front panel locking toggle switch enables or disables detector bias.
- **PUMP/VENT** - Front panel locking toggle switch controls solenoid valve to pump or vent sample chamber.
- **SAMPLE BIAS** - Internal control to adjust sample holder bias from 0 to -12 volts d.c.
- **BIAS VOLTAGE RISETIME** - Internal control to select 1 or 5 minute time constant on detector bias.
- **VACUUM/BIAS INTERLOCK LEVEL** Internal potentiometer adjusts vacuum level at which bias is enabled.

7404-01 AMPLIFIER

- **GAIN** - 4 MeV Full scale to 10 MeV Full scale (10V)
- **OFFSET** - 0 ± 200 mV d.c.

CONNECTORS

7404 CHASSIS (Rear)

- **MULTIFUNCTION** - Provides power, bias and test signals to each of four 7404-01 preamp/amplifiers. Amphenol 17-10090.
- **SAMPLE BIAS** - BNC (factory connected)
- **VALVE** - Molex 03-06-1031 (Factory connected)

7404-01 PREAMP/AMPLIFIER (Rear)

- **MULTIFUNCTION** - Accepts power, bias and test signals from 7404 Amphenol 17-20090.
- **BIAS INPUT** - BNC
- **TEST INPUT** - BNC
- **SIGNAL OUTPUT** - BNC

PHYSICAL

- **WIDTH** - 19 inches
- **HEIGHT** - 7 inches
- **DEPTH** - 14 inches
- **WEIGHT** - 19.5 lbs.

Gas Filled Detectors

For your convenience Canberra Industries provides a complete line of high quality gas filled detectors for use with our NIM and MCA products.

Within each of the listed categories there are numerous detector geometries, various window thicknesses and different gas mixtures from which to choose. Contact your Canberra Representative or the Factory for detailed information on the various detectors available.

Typical Applications

- GM detectors – used for gross radiation counting at low to medium count rates for alpha, beta and gamma radiation. The energy range is dependent on window thickness. They are simple and ideal where spectroscopy is not required and produce large output pulses which require only simple pulse analysis.
- Proportional detectors – used for gross radiation counting at low to high count rates for alpha, beta, gamma and X-rays. The typical energy range for X-ray applications is 0-100keV. Efficiency and energy resolution are superior to scintillation detectors in this energy range.
- Ionization chambers – excellent for low to high level gamma radiation. Because of the short dead time, very high count rates are possible. Ionization chamber output is in the form of very small current pulses consequently high gain amplifiers are required. 10^{-8} to 10^{-12} amps is typical. In recent years, they have become very popular for measuring exposure rates from nuclear reactors and fuel reprocessing facilities.

NaI(Tl) Detectors

Canberra offers a complete line of guaranteed high quality NaI(Tl) scintillation detectors for both gamma and X-ray analysis. As with any of our product lines, performance and durability are variables that must be controlled. The scintillation detectors are no exception.

First of all, each NaI(Tl) crystal is enclosed in a chrome plated aluminum housing. Normally aluminum is porous and susceptible to contamination. By chrome plating the housing, the assembly can be simply wiped clean of contaminations.

Similarly, the light shield around the photomultiplier tube is chrome plated mu metal. Anti-magnetic mu metal minimizes gain changes due to nearby electric motors, unit movement, and the earth's magnetic field.

Secondly, the photomultiplier is an integral part of the hermetic package and cannot be disassembled from the crystal. This configuration always yields the best performance of any scintillation detector package.

Finally, each detector has a resolution which it will meet or exceed, guaranteed in writing.

The NaI(Tl) scintillation crystal is coupled to an SRC multiplier phototube. The SRC tubes have a high quantum efficiency for NaI light emission and are designed for low dark current, good collection efficiency, and high gain stability.

NaI(Tl) scintillation detectors are widely used in gamma spectrometers for numerous applications covering educational physics labs, industry, research and nuclear medicine applications. They offer high counting efficiency and are excellent for timing and high count rate situations where resolution is not the key parameter. When resolution becomes the key parameter, a Ge(Li) detector frequently replaces the NaI(Tl) detector. Refer to the Ge(Li) detector section of this catalog for complete information.

Two series of NaI(Tl) detectors are covered in the catalog, the 800 series and the 1700 series. The 800 series is provided for use in gamma spectrometers while the 1700 series is offered for X-ray applications. They are used in goniometer arms on X-ray diffractometers, X-ray fluorescence and in Mossbauer studies.

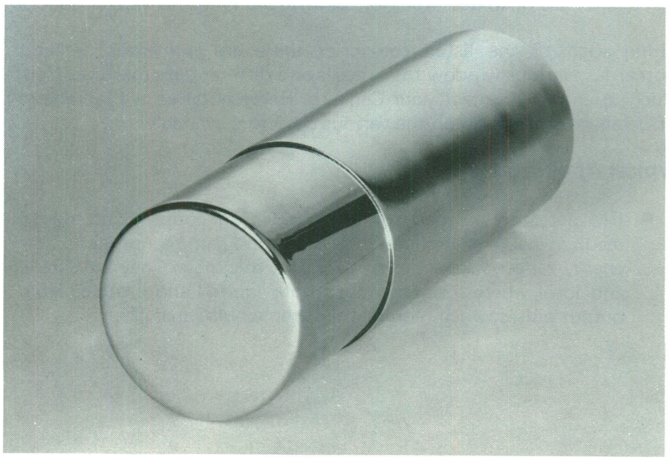
800 Series: Standard diameters of 1.5, 2 and 3" are offered with thicknesses of 1, 2, and 3" respectively. Well detectors and other configurations are available on request.

1700 Series: Standard size, 1" dia. x 1mm thick are offered. Other diameters and thicknesses are available on request. Configurations include models with charge sensitive preamplifier included.

Model 802-1-3-4
Scintillation Detectors

Features

- Guaranteed resolution performance
- Low mass chrome plated housing
- Less than 0.5ppm of Potassium
- Mu metal magnetic light shield



Description

The Model 802 Scintillation Detector is a Monoline Crystal Assembly which includes a high resolution NaI (Tl) crystal, a photomultiplier tube, an internal magnetic/light shield and a chrome plated aluminum housing.

Designed for scintillation counting, the Model 802 assembly has high quantum efficiency, low dark current, good collection efficiency and gain stability and is compatible with the Canberra series of Nuclear Instrument Modules.

Any Model 802 assembly plugs directly into the Model 2007 Tube Base which provides power for the photomultiplier tube. Alternately, the Model 802 can plug into the Model 2007P combination tube base and preamplifier.

Three crystal sizes are available:

Model	Crystal Size	Resolution	Tube Size	Outline Dwg.
802-1	1-1/2 in. x 1 in.	8.5%	2 in.	A
802-3	2 in. x 2 in.	8.5%	2 in.	B
802-4	3 in. x 3 in.	7.5%	3 in.	C

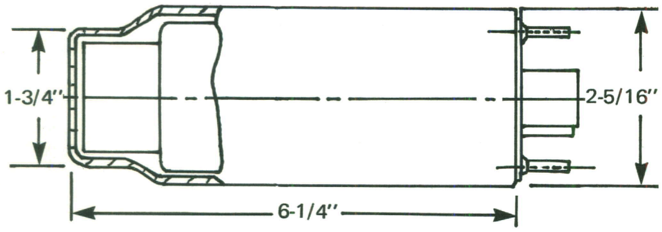
Other configurations are available upon request.

Specifications

RESOLUTION specified at 662keV of Cs-137
WINDOW 0.02 in. aluminum, density 147.9 mg/cm^2
REFLECTOR oxide 1/16 in. thick, density 88 mg/cm^2
MAGNETIC/LIGHT SHIELD Conetic lined steel
TYPICAL OPERATING VOLTAGES:
Cathode to Anode +1100VDC
Dynode to Dynode +80VDC
Cathode to Dynode +150VDC

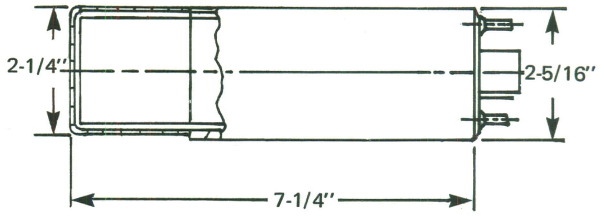
OPTIONS
Model 2007 - tube base, voltage divider, focus control
Model 2007P - tube base, voltage divider, focus control, preamplifier
Model 3002 - High Voltage Supply, NIM
Model 3102 - High Voltage Supply, NIM

OUTLINE DRAWING A



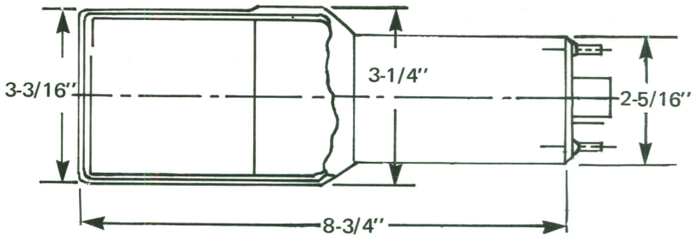
RES ≤8.5%
WEIGHT = 1.7 lbs

OUTLINE DRAWING B



RES ≤8.5%
WEIGHT = 1.7 lbs.

OUTLINE DRAWING C

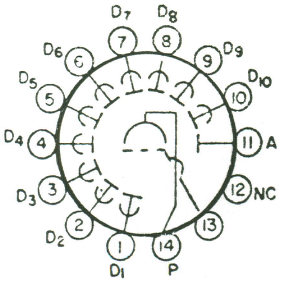


RES ≤7.5%
WEIGHT - 4 lbs.

Specifications(continued)

A, B, and C TUBE BASE

Pin Configuration



BASE: Medium-shell Diheptal 14-pin
JEDEC NO. B14-38
SOCKET: CINCH No. 3M-14

Focus
Electrode

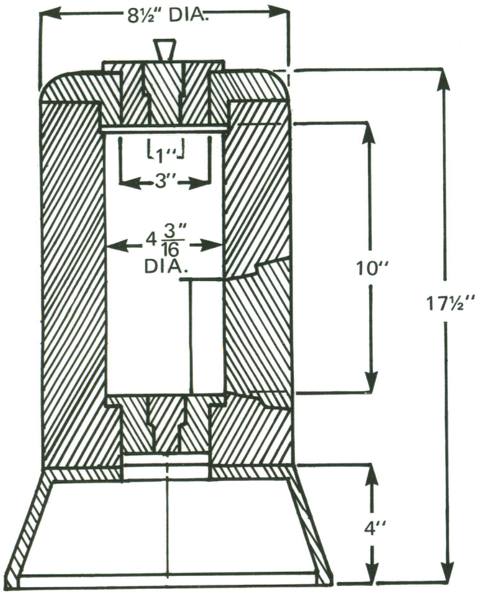
D – DYNODE
A – ANODE
P – PHOTOCATHODE
NC–NO CONNECTION

ACCESSORIES

SHIELDS - the 7410 series of lead shields are made of selected low-level lead. All lead is encased in steel castings to prevent distortion and damage. Handles are cast in the body for ease of handling and are unbreakable.

A removable 3'' plug and two 1'' plugs are provided on top and bottom to provide access for cables and for insertion of a test tube for well counting.

A lucite mount is available (Model 7412) with adjustable shelf heights. To facilitate mounting of larger detectors, various sizes of cork lined clamp rings (Model 7913 are available).
MODEL 7410 - universal lead shield with side door. Accommodates up to 3'' x 3'' NaI detectors. Door opening 4'' x 4''.
7411 - universal lead shield for well detectors (Model 7410 without side door)
7412 - lucite sample shelf for use with 7410 shield. The shelf comes standard and with 9 height adjustments
7413 - cork lined clamp rings to hold detector in shield. Selection of any size depends on orientation of detector. For use with 7410 shield, the 2-5/16'' ring accommodates the Model 802 - 1, 3, and 4. For operation in the 7411 shield (detector faces up) the ring inside diameter must be specified to fit the outside diameter at the crystal end. Standard clamp sizes are 1-3/8'' 2-5/16'' 2-1/2'', 2-3/4''.

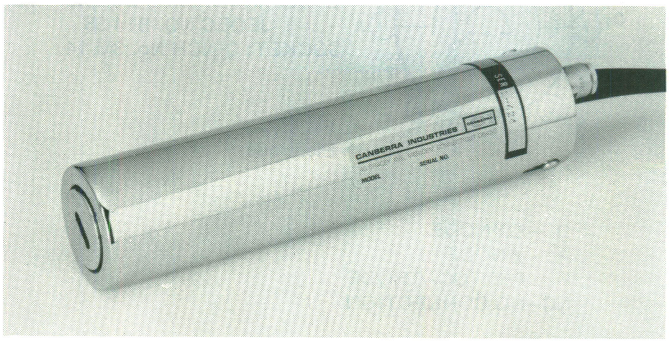


UNIVERSAL LEAD SHIELD

Model 1701, 1702
X-Ray Scintillation Detectors

Features

- Low noise
- Thin window—0.13mm (0.005 in.)
- Removable collimator
- High performance 55% resolution 20:1 peak-to-valley at 5 keV
- Built-in FET Preamplifier—Model 1702


CANBERRA INDUSTRIES
MODEL
SERIAL NO.

Description

The Model 1701 X-Ray Detector is a Monoline Crystal assembly which includes a high resolution [NaI(Tl)] crystal, a photomultiplier tube and voltage divider network. A low noise, charge-sensitive preamplifier is built into the Model 1702.

Featuring a thin Beryllium window (0.13mm [0.005 in.]) these detectors are useful in low energy X-ray counting and spectroscopy applications. Transmission at 3.5 keV is 50% and at 6.0 keV is 88%

A removable brass collimator with a 3 x 13 cm (1/8 x 1/2 in) slit is provided.

Specifications

PERFORMANCE
- **RESOLUTION** - 55% or better at 6 keV
- **PEAK-TO-VALLEY** - 20:1 or better at 6 keV
- **COLLIMATOR** - removable brass 3 x 13 cm (0.125 x 0.5 in.)
- **WINDOW** - 0.13mm (0.005 in.) treated Beryllium
- **CRYSTAL** - NaI(Tl) 2.5 cm (1 in.) diameter x 1 mm (0.039 in.) thick with cleaved surfaces
- **PHOTOMULTIPLIER** — AMPEREX XP1010 selected for low noise
- **VOLTAGE DIVIDER** - 12 pin, 10 stage, low noise

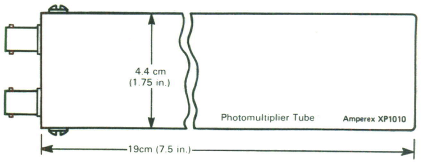
CONNECTORS
- **SIGNAL** - BNC type
- **HIGH VOLTAGE** - SHV type

CABLES Included
- **500 cm (15 foot) BNC**-BNC signal cable
- **500 cm (15 foot) SHV**-SHV high voltage cable

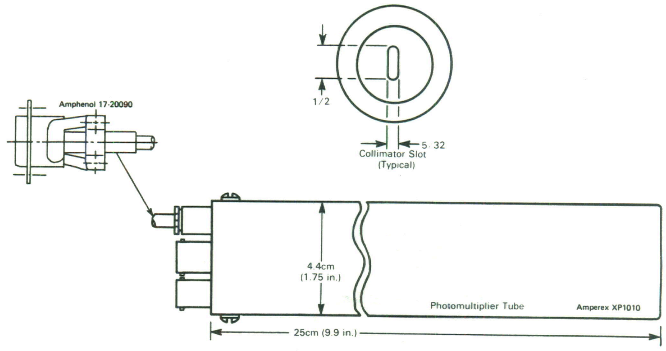
Additional Specifications, Model 1702 Only

CABLE
- **PREAMP POWER** - 15 cm (6 in.) cable terminated with Amphenol #17-20090 connector. A 500 cm (15 foot) preamp power extender cable is provided

PREAMP
- **INPUT** - Charge-sensitive, low noise FET
- **POWER** - requires -24 V dc @ 20 mA on pin 6
- ***OUTPUT*** - 0 to 20 V, 40 nsec rise time, 60 μ sec fall time constant, 50 ohms output impedance


4.4 cm
(1.75 in.)
Photomultiplier Tube
Amperex XP1010
19cm (7.5 in.)

OUTLINE DRAWING 1701


Amphenol 17-20090
1/2
5/32
Collimator Slot
(Typical)
4.4cm
(1.75 in.)
Photomultiplier Tube
Amperex XP1010
25cm (9.9 in.)

OUTLINE DRAWING 1702

Model 2007
PM Tube Base

Features

- Mounts directly on photomultiplier tube (PMT)
- PMT bias operation up to 2kVDC
- Separate focus and gain controls
- Separate anode and dynode outputs

Description

The Canberra Model 2007 is a compact photomultiplier tube base containing a high voltage divider network to supply all the necessary bias voltages for the most common 10-stage PM tubes. A focus control provides for optimization of detector resolution while a gain control permits trimming the H.V. bias when a plurality of tubes must be matched for array setups.

Designed for compatibility with the Canberra Model 802 Series Scintillation detectors, or its equivalent, the tube base connects directly to the PMT providing one integrally mounted assembly. High voltage blocking capacitors are provided to couple the anode and dynode signal outputs to a preamplifier such as the Canberra Model 2005 or Model 2005E, or to timing discriminators such as the Canberra Model 1428.

CANBERRA
GAIN
ANODE
HV
MODEL 2007
FOCUS
DYNODE

Specifications

INPUTS

HV - accommodates PM tube bias up to +2000VDC maximum.

DETECTOR SIGNAL - AC coupled internally to the anode and last dynode, pins 11 and 10 respectively.

OUTPUTS

ANODE - AC coupled; optional 50 ohm output resistance shunt connected.

DYNODE - AC coupled; optional 50 ohm output resistance shunt connected.

CONTROLS

GAIN AND FOCUS - slotted screwdriver adjustments.

PERFORMANCE

DIVIDER BIAS - total resistance 7.2M ohm nominal; 10 dynodes @ 72V per kVDC of detector bias.

FOCUS RANGE - 72V to +145V per kVDC of detector bias.

GAIN RANGE - varies total PM tube bias from between 92% and 100% of applied high voltage.

CONNECTORS

ANODE OUTPUT - BNC.

DYNODE OUTPUT - BNC.

HV - SHV

PM TUBE SOCKET - Cinch Jones 3M-14.

POWER REQUIREMENTS

HV - 0-2kVDC @ 0-300µADC.

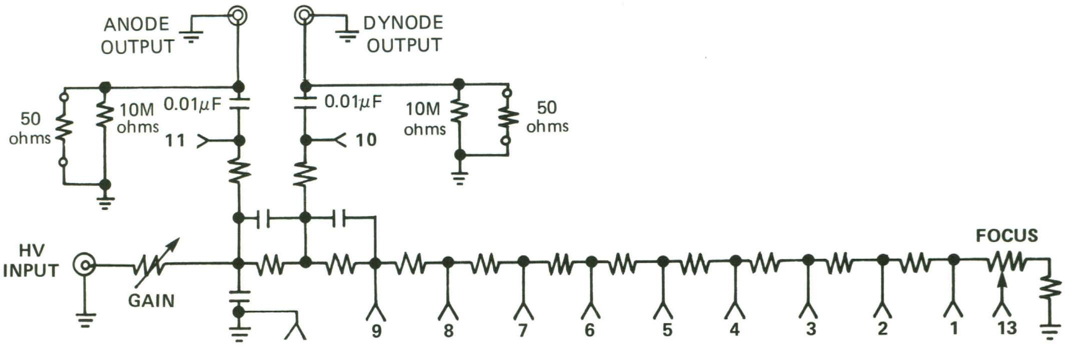
MECHANICAL

DIAMETER - 2.3 in (5.8 cm)

LENGTH - 3 in. (7.6 cm)

NET WEIGHT - 0.5 lb. (0.2 kg.)

SHIPPING WEIGHT - 2.5 lbs. (1.1 kgs.)



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PREAMPLIFIER INTRODUCTION

The primary purpose of the preamplifier in a nuclear research system is to optimize the coupling of a detector's output to the rest of the system. This optimization provides the accurate conversion of the burst of electrons, resulting from the detector's absorption of a particle's energy, into a signal which may be conveniently transmitted to the measurement system. The preamplifier is also required to minimize any sources of noise which may degrade the resolution of the spectrum.

To accommodate the variety of detectors in use today and the stringent requirements of timing and energy resolution, Canberra has developed a complete line of preamplifiers. The preamplifier product line has been refined over a decade of research to insure that the results obtained will not be degraded by any weakness at this crucial point of system interface. Perhaps the most demanding challenge in preamplifier design is to derive a solid, precise output signal from a solid-state detector. A Ge(Li) detector represents an extremely high source impedance ($\sim$10G ohms), appreciable capacitance (10 - 50pF) and generates a small charge (Q) of just 5.4×10^{-14} Coulombs with the absorption of a 1MeV particle.

The total event lasts for periods of from 1 nsec to a few μsec.

$$Q = \frac{\begin{array}{l}\text{1 MeV x charge of an electron:}\\ 1.6 \times 10^{-19}\ \text{Coulombs}\end{array}}{\begin{array}{l}\text{Energy to produce electron-hole}\\ \text{pair in Ge: } 2.98\ \text{eV}\end{array}} = \begin{array}{l}5.4 \times 10^{-14}\\ \text{Coulombs}\end{array}$$

To date, the most effective technique for dealing with these detector characteristics is the FET input, charge sensitive preamplifier. The FET is an inherently low noise device which may be optimized through circuit design, preparation and selection for high gain and low noise for the high impedance detector source. The input charge is integrated in the charge sensitive preamplifier to yield an output equivalent to both the total quantity of input charge and the duration of the event. The charge sensitive system is useful for both timing and energy spectroscopy.

Beyond the careful design of the preamplifier circuit for minimum noise, there are "external" factors which result directly in noise contribution. Input capacitance is a major factor, requiring that a user judiciously choose the detector which best suits his application. The leads connecting the preamplifier to the detector also add input capacitance. Therefore, the preamplifier should be mounted to the detector in as direct a manner as practicable.

SYSTEM NOISE CONTRIBUTION DUE TO INPUT CAPACITANCE

C input pF	Q noise Coulombs	Equiv. FWHM Ge(eV)
0	3.06×10^{-17}	570
10	3.92×10^{-17}	730
30	5.69×10^{-17}	1060
50	7.24×10^{-17}	1350
100	1.18×10^{-16}	2,200

Model 2001 Spectroscopy Preamplifier

Model 2010 Spectroscopy Amplifier

Input capacitance affects not only the energy resolution of the detector system by the addition of noise but the timing resolution as well. Timing is derived from the rise time of the integrated input charge. Both increases in noise and large input capacitance decrease rise time discrimination, thereby reducing timing resolution. Achieving high count rate performance while minimizing noise contribution has traditionally resulted in compromises for preamplifier designers. The preamplifier's internal feedback resistance and the detector bias resistance must be made as large as possible to decrease their noise contribution. Doing so, however, limits the count rate response of the preamplifier. Through circuit refinements and by taking advantage of the great strides being constantly made in semiconductor and component device technology, the point of compromise is being steadily pushed back as is evident in Canberra's Model 2001 Spectroscopy Preamplifier — a new standard in high resolution and high count rate performance.

For low noise, high resolution spectroscopy applications involving Ge(Li) or Silicon Surface Barrier detectors, a low noise preamplifier is a must. The Model 2001/2001A and Model 2003 feature noise performance that is low not only at 0 pF (a reference condition only), but the industry's lowest as influenced by detector and input cable/connector capacitance (See Fig. 1). The circuitry includes a special FET input, carefully optimized for the user needs. Pole/zero cancellation is included which is used at high count rates for optimum overload recovery. All outputs are source matched for driving long cables to remote amplifiers, and are fault protected.

For ease of set up, most preamplifiers include a test input which can be used for system gain (energy) calibration and pole-zero adjustment into the main spectroscopy amplifier.

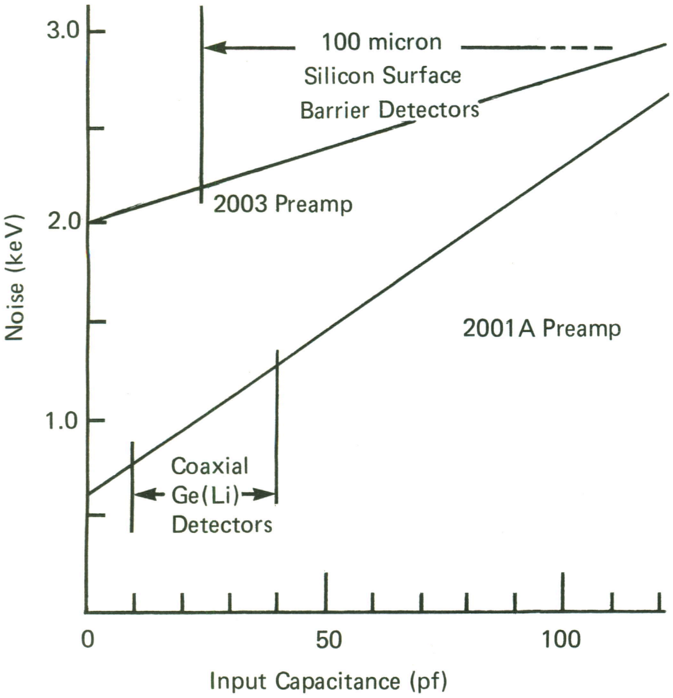


Figure 1. Noise vs Input Capacitance.

Photomultiplier, Gas Proportional and Ionization Chamber Detectors all find a significant place in the Nuclear Market, and Canberra has devoted extensive attention to optimizing charge sensitive preamplifiers for these detectors. The Preview Chart below shows our success using such an approach.

In some applications, the timing of the output signal is the more important parameter. The preamplifier needs to be faster than the charge collection time of the intended detector, but extra speed is traded off against stability, gain and noise. The Model 2003 features a rise time down to 5nsec to accommodate fast Silicon Surface Barrier detectors. The Model 2001 offers a more modest 40nsec rise time, fast enough for Ge(Li) detector work, with noise performance optimized essentially to the state of the art for room temperature (non-cryogenic) preamps. Over the years, Canberra has manufactured many special derivatives for specific needs. The user is invited to inquire about his specific requirements.

To facilitate your selection of the Canberra preamplifier best suited to your requirements, refer to the Canberra Preamplifier Preview Chart below.

CANBERRA PREAMPLIFIER PREVIEW CHART

Preamp Model		Noise (at 0 pF)	Charge or Energy Sensitivity	Charge or Energy Rate Capability	Rise Time	Bias Rating
Ge(Li) Detectors						
2001	d-c coupled	<600eV	100 or 500mV/MeV(Ge)	2 x 10^5MeV/sec	<40ns	5000V
2001A	a-c coupled	<630eV	100 or 500mV/MeV (Ge)	2 x 10^5MeV/sec	<40ns	5000V
Silicon Surface Barrier						
2003		<2keV	20mV/MeV (Si)	2.3 x 10^6MeV/sec	<5ns	2000V
2004	low-cost	<2.8keV	9 or 45mV/MeV (Si)	4.5 x 10^6MeV/sec	<20ns	5000V
Scintillation Detectors						
2005		<1 x 10^{-15} coulomb	4.5mV/picocoulomb	9 x 10^{-6} coulomb/sec	<15ns	
2005E	low-cost	<1 x 10^{-14} coulomb	4.5mV/picocoulomb	3 x 10^{-6} coulomb/sec	<25ns	
2007P	tube base preamp	<1 x 10^{-15} coulomb	4.5mV/picocoulomb		<40ns	2000V
Proportional Counters						
2006		350 ion pairs	47 or 235mV/10^6 ion pair	2 x 10^{-7} coulomb/sec	<20ns	5000V
2006E	low-cost	450 ion pairs	47 or 235mV/10^6 ion pair	1 x 10^{-7} coulomb/sec	<25ns	5000V

Model 1706/1706L
Proportional Counter Preamplifier

Features

- Low Noise FET input with diode protection network
- Ideal for high rate x-ray counting applications
- Charge-sensitive design
- Detector bias operation up to 3kV
- Compact size

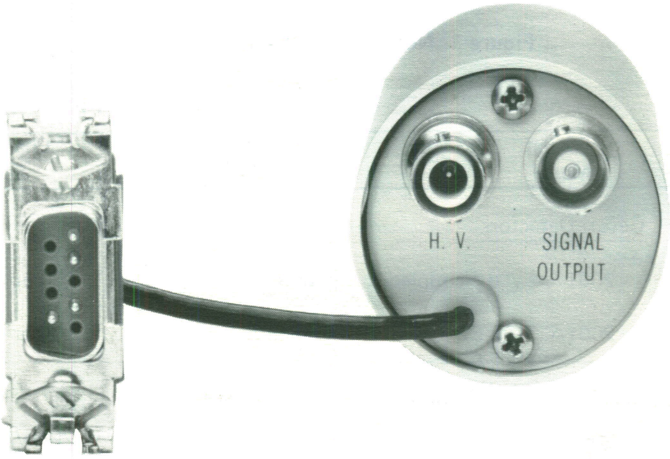
DETECTOR
MODEL 1706L
COUNTER PREAMP
CANBERRA

Description

The Canberra Model 1706 has been specifically designed to optimize the performance of X-Ray systems employing proportional counter detectors. Incorporated in the Model 1706 are pulse shaping components carefully selected to match the typical output characteristics of sealed or flow proportional counters to provide maximum count-rate linearity. When used with the Model 1718 X-Ray Amplifier/Pulse Height Analyzer, average count rates in excess of 50,000 cps can be processed with under 1% count loss due to pulse pileup.

The preamplifier input stage uses an FET to insure lowest noise contribution. A diode network protection circuit is employed to prevent FET damage due to sudden application or removal of detector bias.

The Model 1706 has an output impedance of 93 ohms and can drive long coaxial cables. Its very small size and protected input makes the Model 1706 ideal for applications requiring the preamplifier to be installed in inaccessible positions requiring unattended operation.



Specifications

INPUTS

DETECTOR INPUT - charge pulse from detector, AC coupled

HV INPUT - detector bias voltage, 0 to ±3000VDC; no limit to the rate at which bias may be applied

OUTPUTS

SIGNAL - provides output pulses of up to ±4V (open circuit); fall time constant is nominally 3μsec (1706L: nominal 50μsec); output impedance is 93 ohms, series connected, DC coupled

PERFORMANCE

INTEGRAL NONLINEARITY - less than ±0.1%

GAIN STABILITY - better than ±50ppm/°C

DETECTOR BIAS ISOLATION - ±3000 VDC

CHARGE SENSITIVITY - 1 volt/picocoulomb, or 0.33 volt/picocoulomb (internally selected), inverting

PULSE RISE TIME - less than 90nsec

NOISE OUTPUT - less than 3×10^{-16} coulomb RMS referred to input

CONNECTORS

DETECTOR, H.V. - SHV

SIGNAL - BNC

POWER CABLE - 6" compatible cable with Amphenol #17-20090 9-pin connector and 15 foot extender cable, both shielded

POWER REQUIREMENTS

+12VDC — 20mA - 12VDC — 15mA

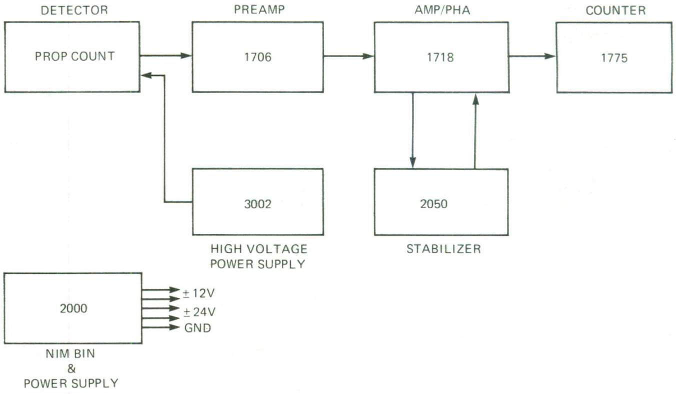
PHYSICAL

SIZE - 2.75 inches long, 1.62 inches in diameter, (6.99 cm x 4.11 cm) spun aluminum housing

NET WEIGHT - 0.9 lbs. (0.36 kg)

SHIPPING WEIGHT - 3 lbs. (1.35 kgs.)

TYPICAL X-RAY COUNTING SYSTEM

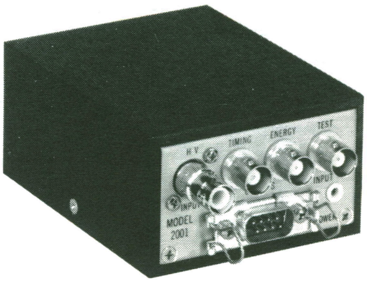


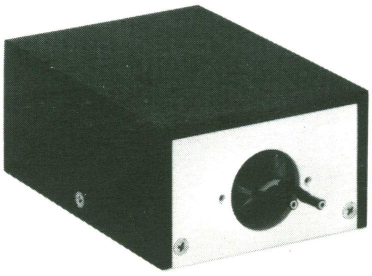
Model 2001/2001A
Ge(Li) Detector Preamplifier

Features

- Low noise design: better than 600eV (Ge) @ $C_S = 0pF$
- Count rate capability >200,000cps (^{60}Co)
- Detector bias filter rated to ±5000VDC
- Fast rise time: better than 40nsec @ $C_S = 0 - 30pF$
- Direct coupled charge sensitive input circuit; optional AC coupling
- Pole/Zero cancelled unipolar output pulse
- Separate terminated energy and timing outputs

DETECTOR INPUT
MODEL 2001A





Description

The Canberra Model 2001 represents the latest advance in charge sensitive preamplifiers. It was designed primarily for high resolution gamma spectroscopy using cooled Ge solid state detectors. The preamplifier converts the ionization charge developed in the detector during each absorbed nuclear event to a step function pulse output whose amplitude is proportional to the total charge accumulated in that event. The pulse decays exponentially with a time constant of 50 microseconds (nominal) to segregate successive events in high count rate applications.

The design of the Model 2001 includes a FET input circuit optimized to the ultra-high source impedance characteristics of Ge detectors. As can be seen in the functional schematic (Figure 1), the first stage functions as an operational integrator yielding an output voltage proportional to the accumulated charge. The second stage functions as a selectable gain differentiator/buffer and provides the separately terminated Energy and Timing outputs. Conversion factors of nominally 100mV/MeV or 500mV/MeV (Ge) are selected by a jumper plug on the printed circuit board inside the unit. The higher scale factor is especially useful for best signal-to-noise ratio in experiments involving low energy sources. The differentiator circuit includes a Pole/Zero adjustment to return the unipolar pulse signal to a reference or baseline level without overshoot. The first stage output is available at a rear panel test jack for detector/preamplifier troubleshooting. The V-I characteristics of the detector can be readily checked by measuring the test-point voltage as a function of detector bias voltage.

The Model 2001 is offered in two configurations: the standard unit is direct coupled at the input, for installations in which both terminals of the detector are electrically isolated from ground and in which the preamp can be directly mounted to the neck of the cryostat; the 2001A is capacitor coupled between the detector and preamp, for installations in which one terminal of the detector is grounded or in which the detector must be connected through cabling.

The performance of the Model 2001 is the current state of the art for room temperature (non-cooled) preamps. The noise level for the 2001 version (direct coupled) is equivalent to less than 600eV FWHM(Ge) with a source capacitance of 0pF, using 2 microsecond near-Gaussian pulse shaping, and degrades at less than 17eV/pF. The 2001A (AC coupled) offers less than 630eV FWHM(Ge), the difference is due to the current noise in the detector bias resistor and the additional capacitance at the input using the SHV connector. Typical noise performance with other pulse shaping time constants can be seen in Figure 2.

The count rate capability of the Model 2001 has been demonstrated in excess of 200,000 counts per second using a ^{60}Co gamma energy source (1.33MeV peak). The fast rise time is maintained over a wide range of detector source capacitance, and is more than adequate for the charge collection times of planar or coaxial Ge detectors.

In order to take advantage of the high count rate capability of the 2001, a high count rate main shaping amplifier, such as the Canberra Model 2020, is recommended. Other amplifiers may have count rate limits of their own. Timing analysis may be done with such units as the Canberra Model 2110 Timing Filter Amp, or other NIM modules as needs dictate. At low energies, the system timing performance may benefit from the higher gain setting of 500mV/MeV.

A test input is provided on the Model 2001 to assist system setup and simplify troubleshooting. The test capacitor value is certified in the unit test report for reference use as a secondary charge calibration standard. The nominal voltage gain through the preamplifier from the test input is 1X for the output scale factor of 100mV/MeV, and 5X for the output scale factor of 500mV/MeV.

Power for the Model 2001 is usually supplied from the associated Canberra pulse shaping amplifier. The power lines are filtered within the Model 2001 to provide high noise immunity. A ten foot power cable is provided with the preamp.

Specifications

INPUTS

DETECTOR INPUT - charge pulse from a cooled Ge detector

TEST INPUT - charge coupled to preamp input at 0.5 picocoulomb/V nominal: voltage gain to outputs 1X or 5X (as selected), ±30%. Input impedance is 93 ohms

HV INPUT - detector bias voltage, 0 to ±5000VDC; no limit to the rate at which bias may be applied; series resistance to detector bias point is 10,000 Megohms nominal; filter time constant is 10 seconds nominal.

OUTPUTS

ENERGY OUTPUT - unipolar pulses linearly proportional in peak amplitude to charge input, non-inverting; decay time constant is 50 microseconds (±10%); output swing range ±10V open circuit; output impedance, 93 ohms, series connected, DC coupled; output level 0 ±75mVDC (at gain of 100mV/MeV), or 0 ±300mVDC (at gain of 500mV/MeV)

TIMING OUTPUT - unipolar pulse for each input event; signal parameters same as above, except 50 ohm output

PERFORMANCE

INTEGRAL NONLINEARITY - less than ±0.05% for ±8V output swing

GAIN STABILITY - better than ±0.005%/°C (±50 ppm/°C), range 0 to +50°C; better than ±0.01% over 24 hours at constant temperature after 1 hour stabilization

CHARGE SENSITIVITY - 2 V/picocoulomb, or 10 V/picocoulomb, corresponding to 100mV/MeV, or 500mV/MeV Ge nominal, as selected by jumper plug on printed circuit board internal to unit; gain tolerance ±25%

NOISE PERFORMANCE - using a Canberra Model 2020 Spectroscopy Amplifier set at 2 microsecond unipolar near-Gaussian pulse shaping, noise behavior is as follows:

C_{source} in picofarads	for		Noise in Coulombs, RMS	keV, FWHM *
0	2001:	typical	1.3×10^{-17}	570
		maximum	1.4×10^{-17}	600
	2001A:	typical	1.4×10^{-17}	600
		maximum	1.4×10^{-17}	630
100	2001:	typical	5.0×10^{-17}	2,200
		maximum	5.2×10^{-17}	2,300
	2001A:	typical	5.1×10^{-17}	2,250
		maximum	5.3×10^{-17}	2,340

* based upon 2.98 eV/ion-pair in Ge @77°K

RISE TIME - less than 40nsec with C_{source} = 0pF, and less than 50nsec with C_{source} = 100pF

COUNT RATE CAPABILITIES - ≈200,000 counts per second for a ^{60}Co source (1.33 MeV), averaged at rate of 75,000 MeV/sec.

POWER REQUIREMENTS

+12VDC	10mA	+24VDC	30mA
-12VDC	5mA	-24VDC	10mA

CONNECTORS

DETECTOR INPUT - on 2001 — 1 inch (nominal) leads with Augat LSG-3CG1-1 sockets (fit .040" dia. pins): on 2001A — SHV with dust cap and chain.

HV INPUT - SHV

TEST INPUT - BNC

POWER INPUT - Amphenol 17-20090

ENERGY OUTPUT - BNC

TIMING OUTPUT - BNC

PHYSICAL

SIZE - See Figure 3 for outline details

NET WEIGHT - 0.81 lbs. (0.37 kg)

SHIPPING WEIGHT - approx. 0.81 lbs. (0.54 kg)

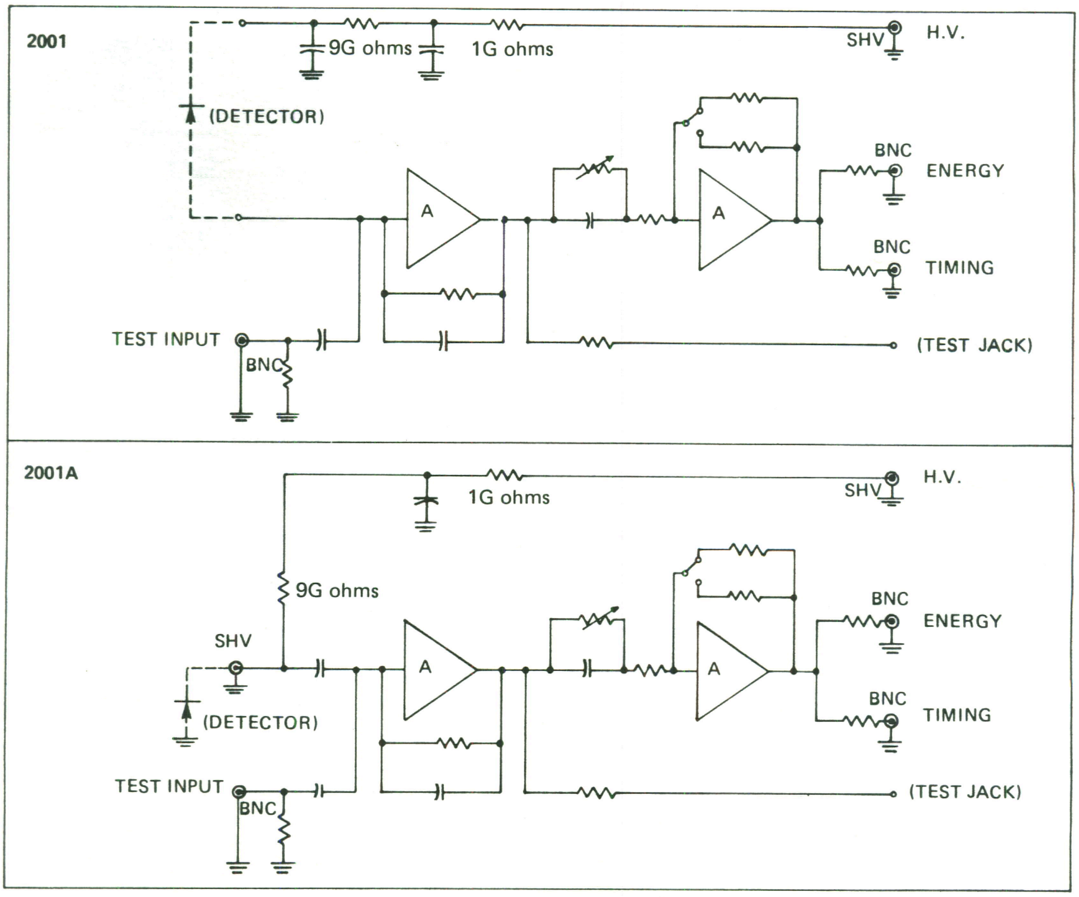


Figure 1. Functional Schematic, Model 2001.

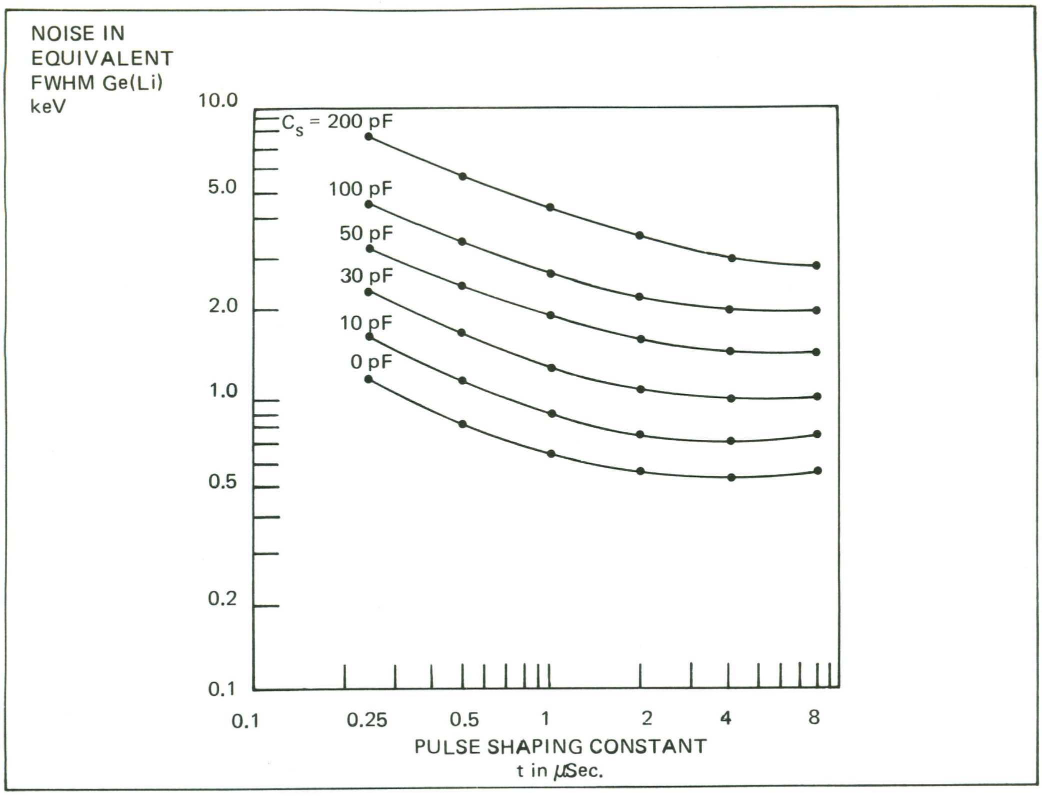
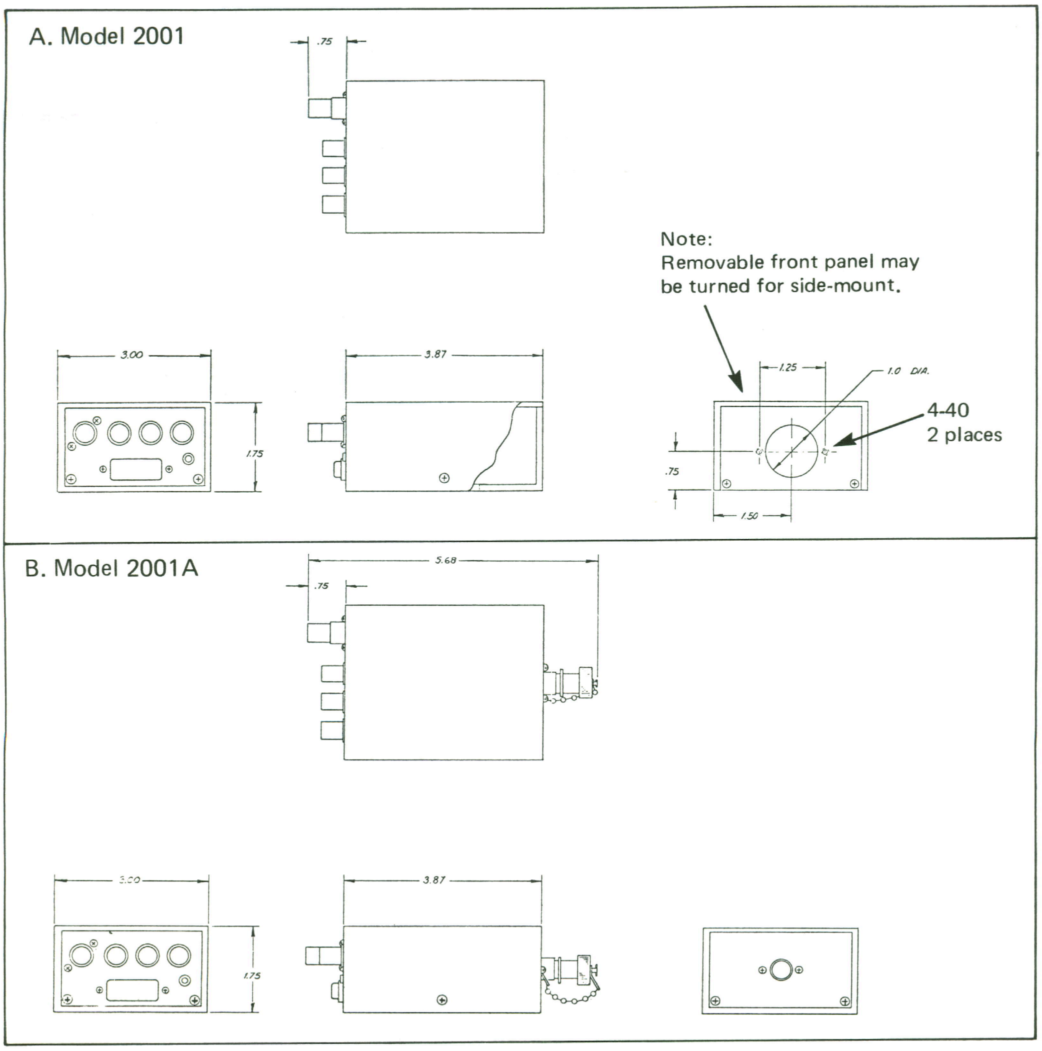


Figure 2. Typical Electronic Noise Behavior of Model 2001 for various pulse shaping time constants.


A. Model 2001
.75
3.00
1.75
3.87
1.25
1.0 DIA.
4-40
2 places
.75
1.50
B. Model 2001A
5.68
.75
3.00
1.75
3.87

Note:
Removable front panel may be turned for side-mount.

Figure 3. Outline Drawing.

Model 2003T/2003BT Silicon Surface Barrier Detector Preamplifier

Features

- Low noise design: less than 2.0keV (Si) @ 0pF
- High energy rate capability: up to 2×10^6MeV per second
- FET input, diode protected
- Independent energy and fast timing outputs
- Fast rise time <3ns @ 0pF
- Small size
- Capable of operating in a vacuum chamber

Description

The Canberra Model 2003T/2003BT charge sensitive FET input preamp is designed for optimum performance with Silicon Surface Barrier (SSB) detectors. Operating as a charge to voltage converter, the unit accepts charge carriers produced in the detector during each absorbed nuclear event. The output then provides a voltage in direct proportion to the collected charge at the rate of 0.45V per picocoulomb. This translates to a gain of 20mV per MeV for room temperature silicon detectors.

The Model 2003 provides an SHV input connector, while the Model 2003B provides a BNC input connector for convenient interface to vacuum chamber feedthroughs.

For typical use with positively biased SSB detectors, the extremely linear energy output provides a positive polarity pulse ideal for energy spectroscopy. The coincident timing output provides a negative polarity fast differentiated pulse ideal for resolution of nuclear events in time.

The high charge rate capability of the design is evidenced by an energy rate capacity of greater then 2×10^6MeV per second when used with silicon detectors. In order to take full advantage of such a high count rate capability, a main amplifier with a correspondingly high count rate ability, such as the Canberra Model 2020, should be used.

The basic operation of the preamplifier is indicated in the functional schematic. The first stage acts as an operational integrator which produces an output potential proportional to the accumulated charge on the feedback capacitor C_f. The integrator drives the energy output directly. The timing output is derived from the integrator error signal through a pulse shaping network. Such an arrangement allows for the low noise and fast rise times as in Table 1. To preserve pulse fidelity the energy output is buffered through a series terminating resistor of 93 ohms.

The preamplifier offers a noise contribution of only 2.0keV, FWHM, Si, with a rate of increase with increasing input capacitance of ≤10eV per picofarad. All necessary power is provided by a Canberra main amplifier through the ten foot compatible cable furnished with the preamp.

Specifications

INPUTS

DETECTOR INPUT - accepts charge pulse from semiconductor detectors including SSB types.

HV INPUT - allows detector biasing up to ±2000VDC; detector series bias resistance is 110M ohms.

POWER INPUT -	+24V	-24V	+12V	-12V
	10mA	4mA	30mA	6mA

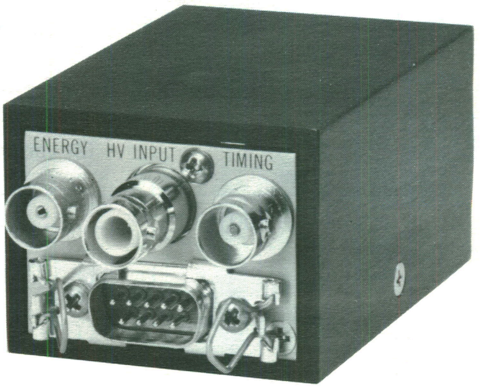
Supplied from associated Canberra main amplifier or MCA

OUTPUTS

ENERGY OUTPUT - inverted with a tail pulse time constant of 250μsec and an amplitude of up to ±10V unterminated; output impedance 93 ohms, direct coupled. Rise time as in Table 1. DC offset adjustable to zero.

TIMING OUTPUT - non-inverted, fast differentiated pulse with rise time as in Table 1 and fall time variable. Direct coupled current source output to drive 50 ohm load.

DETECTOR INPUT
MODEL 2003T
CANBERRA



PERFORMANCE

INTEGRAL NONLINEARITY - ≤±0.04% for ±10V output.

GAIN DRIFT - ≤±0.005% per °C (±50ppm/°C), 0-50°C.

DETECTOR BIAS ISOLATION - ±2000VDC maximum.

NOISE - See Table 1.

CHARGE SENSITIVITY - 0.45V/pC.

ENERGY SENSITIVITY - 20mV/MeV (Si).

RISE TIME - See Table 1.

CONNECTORS

POWER - Amphenol 17-20090

DETECTOR - SHV for Model 2003, and BNC for Model 2003B.

HV INPUT - SHV

ENERGY AND TIMING OUTPUTS - BNC.

Ten foot compatible preamp power cable with required connectors is supplied with the preamplifier.

PHYSICAL

SIZE - 3 x 1.75 x 1.25 inches (7.6 x 4.4 x 3.2 cm).

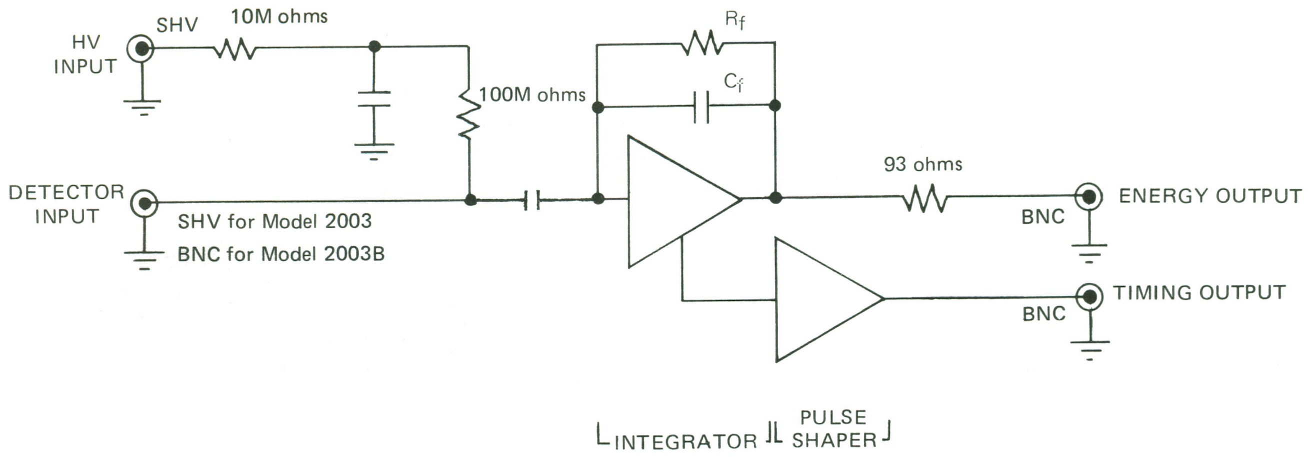
NET WEIGHT - 8 ounces (0.23 kg).

SHIPPING WEIGHT - 14 ounces (0.39 kg).

TABLE 1

C source in picofarads	Noise in keV FWHM, Si	Rise Time in nanoseconds Energy Output	Timing Output
0	<2.0	<12	< 3
100	<3.0	<14	< 4
500	<6.5	<22	<10
1000	<9.5	<28	<16

NOTE 1: Noise performance measured using Canberra Model 2020 Spectroscopy Amplifier set at 2 microsecond unipolar near-Gaussian shaping.


HV INPUT
SHV
10M ohms
100M ohms
Rf
Cf
DETECTOR INPUT
SHV for Model 2003
BNC for Model 2003B
93 ohms
ENERGY OUTPUT
BNC
TIMING OUTPUT
BNC
INTEGRATOR
PULSE SHAPER

FUNCTIONAL SCHEMATIC

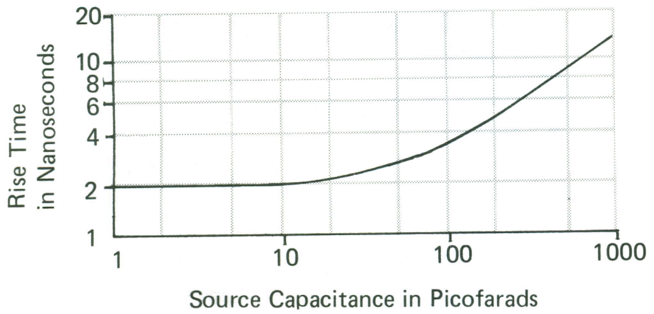


Figure 1. Typical Rise Time vs. Source Capacitance for the Timing Output.

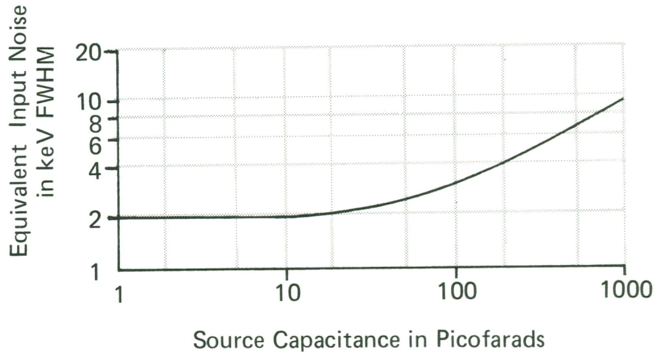
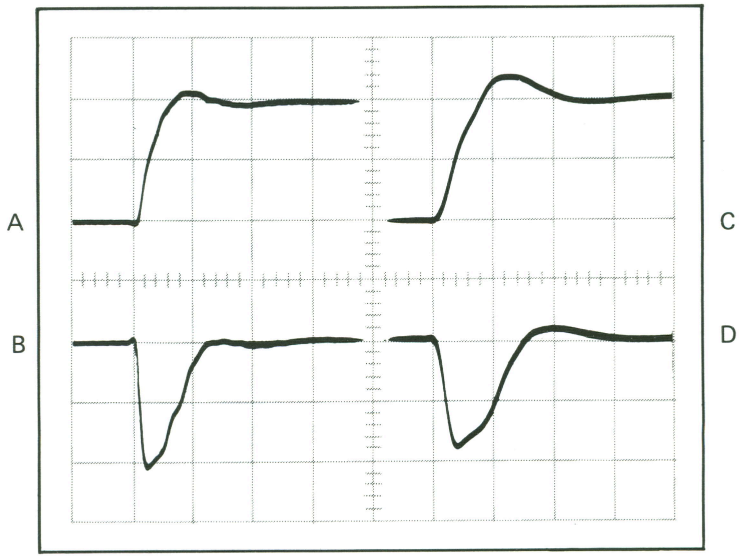


Figure 2. Typical Noise Performance vs. Source Capacitance for the Energy Output
See Note 1 for test conditions.



Vertical Sensitivity	50mV/div
Horizontal Sensitivity	20ns/div.

Figure 3. Pulse Response: **(A) Energy Output and (B) Timing Output with C_{source} = 10pF**
(C) Energy Output and (D) Timing Output with C_{source} = 100pF

Model 2004
Semiconductor Detector Preamplifier

Features

- Low noise design: less than 2.8keV (Si) @ 0 pf
- High charge rate capability: up to 4.5 x 10^6 MeV/sec
- FET input, diode protected
- Pole/zero select or defeat
- High voltage operation up to ±5000VDC

Description

The Canberra Model 2004 charge sensitive FET input preamplifier was designed for use with both low and high capacitance semiconductor detectors. The preamp converts the charge carriers developed in the detector during each absorbed nuclear event to a step function voltage pulse, the amplitude of which is proportional to the total charge accumulated in that event. The pulse decays with a nominal time constant of 50 microseconds, for presentation to a main amplifier.

For the typical use with a positive polarity HV bias to a silicon surface barrier detector for high energy alpha spectroscopy analysis, the preamplifier provides a positive polarity energy pulse output.

The high charge rate capability of the design is evidenced by a charge rate capacity of better than 2 x 10^{-7} coulombs per second, or 4.5 x 10^6MeV per second for silicon detectors. In order to take full advantage of such a high count rate capability, a main amplifier with a correspondingly high count rate ability, such as the Canberra Model 2020, should be employed.

As shown in the functional schematic the first stage acts an operational integrator which produces an output potential proportional to the accumulated charge. This integrator is coupled to an output buffer stage thru a pole/zero trim network. A feature of particular importance to certain users is a removable socketed resistor on the printed circuit board for disabling the pole/zero circuit. In addition, the input circuit includes a protection network to prevent damage to the input FET from transient high voltage waveforms caused by sudden application or removal of detector bias, or a detector fault.

The preamplifier offers a noise contribution of only 2.8keV, FWHM, Si, with a rate of noise increase with increasing input capacitance of only 10eV per picofarad, FWHM, Si. Conversion gains of nominally 9mV per MeV or 45mV per MeV (Si) may be selected by a jumper plug on the printed circuit board inside the unit. All necessary power is provided by a Canberra main amplifier through the ten foot compatible cable provided.

Specifications

INPUTS

DETECTOR INPUT - Accepts charge pulse from semiconductor detector.

TEST INPUT - Charge coupled to preamp input @ 2.2 picocoulombs per volt; input impedance 93 ohms.

HV INPUT - Allows detector biasing up to ±5000VDC; detector series bias resistance 110M ohms.

POWER -	+24V	- 24V	+12V	- 12V
	30mA	30mA	2mA	2mA

supplied from associated Canberra main amplifier or MCA.

OUTPUTS

ENERGY OUTPUT - Inverted tail pulse, rise time as in Table 1, 50μsec fall time constant, up to ±10V; output impedance 93 ohms, direct coupled.

DETECTOR INPUT
MODEL 2004
CANBERRA
HV INPUT
OUTPUT
TEST INPUT
MODEL 2004

PERFORMANCE

INTEGRAL NONLINEARITY - <±0.02% for ±10V output.

GAIN DRIFT - <±0.01% per °C (±100ppm/°C).

DETECTOR BIAS ISOLATION - ±5000VDC maximum.

NOISE OUTPUT PERFORMANCE - See Table 1.

CHARGE SENSITIVITY - 0.2V/pC or 1.0V/pC, internally selected.

ENERGY SENSITIVITY (Si) - 9mV/MeV or 45mV/MeV, internally selected.

RISETIME - See Table 1.

CONNECTORS

POWER - Amphenol 17-20090.

DETECTOR INPUT, HV INPUT - SHV.

TEST INPUT, ENERGY OUTPUT - BNC.

Ten foot compatible preamp power cable with required connectors is supplied with the preamplifier.

PHYSICAL

SIZE - 3 x 4 x 1.75 inches (7.6 x 10.2 x 4.4 cm).

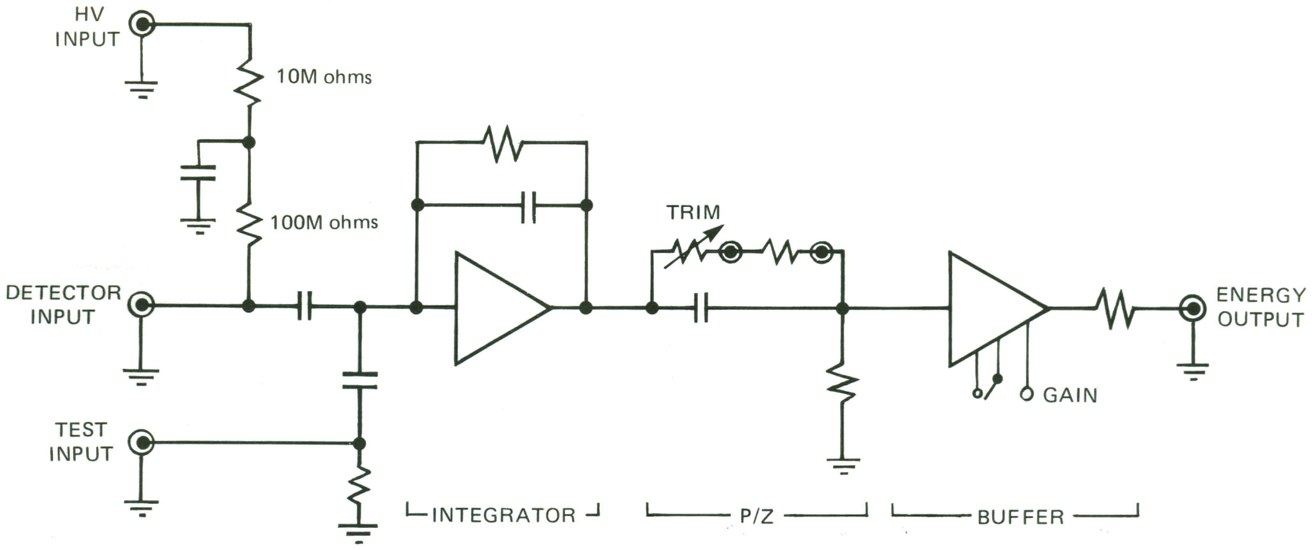
NET WEIGHT - 12 ounces (0.34 kg).

SHIPPING WEIGHT - Approximately 18 ounces (0.5 kg).

TABLE 1

C source in picofarad	**Noise in Coulombs RMS**	**Noise in KeV, FWHM, Si**	**Rise Time in nanoseconds**
0	$<5.3 \times 10^{-17}$	<2.8	<20
30	$<5.7 \times 10^{-17}$	<3.0	<21
100	$<6.6 \times 10^{-17}$	<3.5	<23
300	$<1.0 \times 10^{-17}$	<5.3	<33

Noise performance using Canberra Model 2020 spectroscopy amplifier with 2μsec, unipolar, near-Gaussian shaping.


HV INPUT
10M ohms
100M ohms
DETECTOR INPUT
TEST INPUT
TRIM
GAIN
ENERGY OUTPUT
INTEGRATOR
P/Z
BUFFER

FUNCTIONAL SCHEMATIC

Model 2005
Scintillation Preamplifier

Features

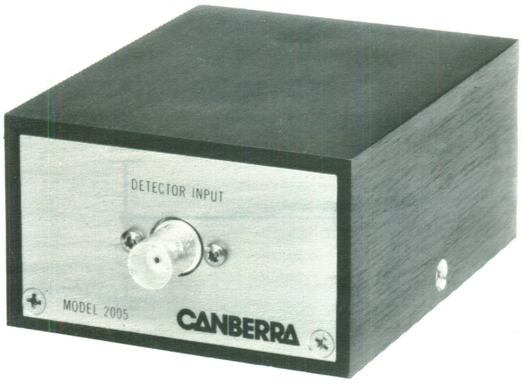
- Low noise design: less than 10^{-15} coulombs RMS
- High charge rate capacity (up to 9 microcoulombs/sec) for high count rate applications
- FET input, diode protected
- Fast risetime: less than 15nsec

Description

The Canberra Model 2005 is a charge sensitive preamplifier which collects the charge output from scintillation/photomultiplier detectors for presentation to a pulse shaping main amplifier. For the typical application with input from the decoupled anode signal from a photomultiplier tube base, the preamplifier generates a positive polarity energy pulse output.

Functionally the unit operates as an integrator utilizing an operational type configuration by which the potential difference across the feedback capacitor is directly proportional to the charge accumulated from the detector input. The integrator is followed by a pole/zero cancellation circuit for optimum overload performance, and a differentiator to provide the 50 microsecond tail pulse. In addition a buffer stage allows the Model 2005 to drive long cable lengths without pulse degradation.

Charge conversion gains of nominally 4.5 or 22.7 millivolts per picocoulomb may be selected by a jumper plug on the printed circuit board inside the unit. Power for the unit is usually supplied from the associated main amplifier through the ten foot power cable provided with the preamp.



OUTPUT
TEST INPUT
MODEL 2005

Specifications

INPUTS

DETECTOR INPUT - Accepts charge pulse from scintillation/photomultiplier detector.

TEST INPUT - Charge coupled to preamp input @ 33 picocoulombs per volt; input impedance 93 ohms.

POWER -

+24V	-24V	+12V	-12V
20mA	14mA	2mA	2mA

supplied from Canberra main amplifier or MCA.

OUTPUTS

ENERGY OUTPUT - Inverted tail pulse, rise time as in Table 1, 50μsec falltime constant, up to ±10V; output impedance 93 ohms, direct coupled.

PERFORMANCE

INTEGRAL NONLINEARITY - ≲±0.02% for up to ±10V output.

GAIN DRIFT - ≲±0.01% per °C (±100ppm/°C).

NOISE OUTPUT PERFORMANCE - See Table 1.

CHARGE SENSITIVITY - 4.5mV/pC or 22.7mV/pC, internally selected.

HIGH CHARGE RATE CAPABILITY - Up to 9 microcoulombs/sec.

CONNECTORS

POWER - Amphenol 17-20090.

DETECTOR INPUT, TEST INPUT, ENERGY OUTPUT - BNC.

Ten foot compatible preamplifier power cable with required connectors is supplied with the preamp.

PHYSICAL

SIZE - 3 x 4 x 1.75 inches (7.6 x 10.2 x 4.4 cm).

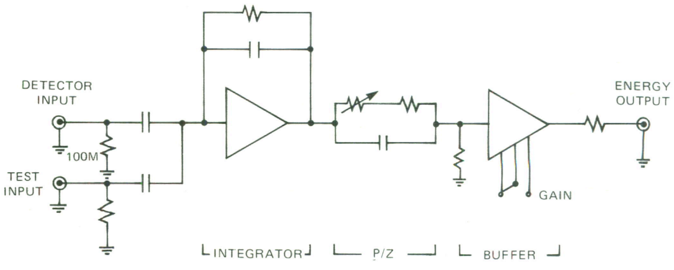
NET WEIGHT - 11 ounces (0.31 kg).

SHIPPING WEIGHT - Approximately 17 ounces (0.48 kg).

TABLE 1

C source in picofarads	Noise in coulombs RMS	Rise Time in nanoseconds
0	1×10^{-15}	≲15
500	1.5×10^{-15}	≲16

Noise performance measured using Canberra Model 2020 Spectroscopy Amplifier set a 2 microsecond unipolar, near-Gaussian shaping.

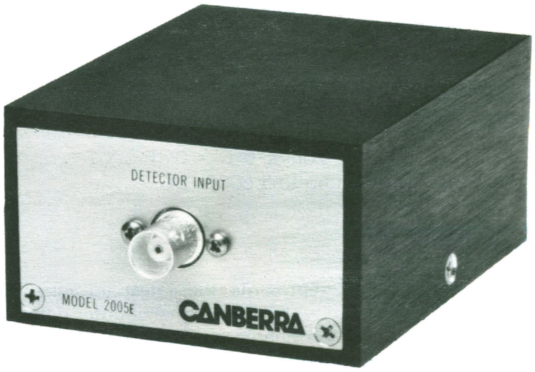


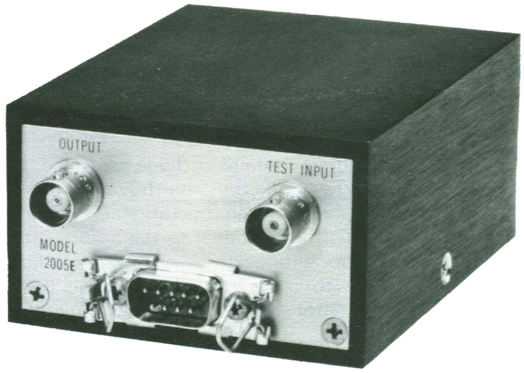
FUNCTIONAL SCHEMATIC

Model 2005E
Scintillation Preamplifier

Features

- Low noise design: less than 10^{-14} coulombs RMS
- High charge rate capacity (up to 3 microcoulombs/sec) for high count rate applications
- FET input, diode protected
- Fast risetime: less than 25nsec





Description

The Canberra Model 2005E is a charge sensitive preamplifier which collects the charge output from scintillation/photomultiplier detectors for presentation to a pulse shaping main amplifier. For the typical application with input from the decoupled anode signal from a photomultiplier tube base, the preamplifier generates a positive polarity energy pulse output.

Functionally the unit operates as an integrator utilizing an operational type configuration by which the potential difference across the feedback capacitor is directly proportional to the charge accumulated from the detector input. The integrator is followed by a pole/zero cancellation circuit for optimum overload performance, and a differentiator to provide the 50 microsecond tail pulse. In addition a buffer stage allows the Model 2005E to drive long cable lengths without pulse degradation.

Charge conversion gains of nominally 4.5 or 22.7 millivolts per picocoulomb may be selected by a jumper plug on the printed circuit board inside the unit. Power for the unit is usually supplied from the associated main amplifier through the ten foot power cable provided with the preamp.

Specifications

INPUTS

DETECTOR INPUT - Accepts charge pulse from scintillation/photomultiplier detector.

TEST INPUT - Charge coupled to preamp input @ 33 picocoulombs per volt; input impedance 93 ohms.

POWER -

+24V	-24V	+12V	-12V
20mA	14mA	2mA	2mA

supplied from Canberra main amplifier or MCA.

OUTPUTS

ENERGY OUTPUT - Inverted tail pulse, rise time as in Table 1, 50μsec falltime constant, up to ±10V; output impedance 93 ohms, direct coupled.

PERFORMANCE

INTEGRAL NONLINEARITY - <±0.08% for up to ±10V output.

GAIN DRIFT - <±0.02% per °C (±200ppm/°C).

NOISE OUTPUT PERFORMANCE - See Table 1.

CHARGE SENSITIVITY - 4.5mV/pC or 22.7mV/pC, internally selected.

HIGH CHARGE RATE CAPABILITY - Up to 3 microcoulombs/sec.

CONNECTORS

POWER - Amphenol 17-20090.

DETECTOR INPUT, TEST INPUT, ENERGY OUTPUT - BNC.

Ten foot compatible preamplifier power cable with required connectors supplied with the preamp.

PHYSICAL

SIZE - 3 x 4 x 1.75 inches (7.6 x 10.2 x 4.4 cm).

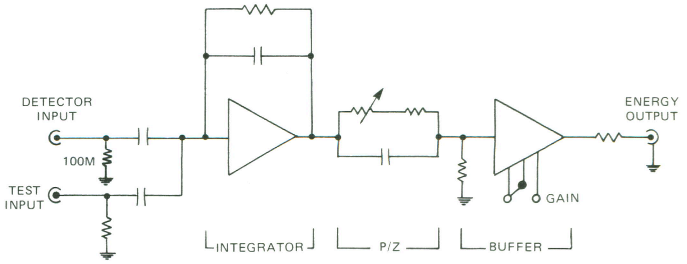
NET WEIGHT - 11 ounces (0.31 kg).

SHIPPING WEIGHT - Approximately 17 ounces (0.48 kg)

TABLE 1

C source in picofarads	**Noise in coulombs RMS**	**Rise Time in nanoseconds**
0	$< 1 \times 10^{-14}$	<25
500	$< 1.5 \times 10^{-14}$	<30

Noise performance measured using Canberra Model 2020 Spectroscopy Amplifier set a 2 microsecond unipolar, near-Gaussian shaping.



FUNCTIONAL SCHEMATIC

Model 2006
Proportional Counter Preamplifier

Features

- Low noise design: less than 350 ion pairs @ $C_S = 0$ pF
- High charge rate capacity (up to 2 x 10^{-7} coulombs/sec) for high count rate applications
- FET input, diode protected
- Fast risetime: less than 20nsec @ $C_S = 0$ pF
- High voltage operation up to ±5000VDC

Description

The Canberra Model 2006 represents the latest advance in charge sensitive preamplifiers for use with proportional counter detectors. The preamp converts the ionization charge from the detector into a step voltage pulse whose amplitude is proportional to the total charge collected in each event. The pulse decays with a time constant of 50 microseconds for presentation to a main amplifier.

For typical use with a positive polarity HV bias to the anode of the detector, the preamplifier generates positive polarity energy pulses which are shaped in the amplifier as necessary for counting or low energy X-ray analysis.

The Model 2006 preamplifier contains a diode-protected FET input stage optimized for low noise operation. As shown in the functional schematic the first stage acts as an operational integrator which produces an output potential proportional to the accumulated charge. This integrator configuration is followed by a pole/zero adjustment to return the unipolar pulse to a reference or baseline level without overshoot, and a differentiator to provide the 50 microsecond tail pulse. The second active stage operates as a buffer for driving various cable lengths without pulse degradation. Conversion gains of nominally 47mV/M ion pair or 235mV/M ion pair may be selected by a jumper plug on the printed circuit board inside the unit. The higher scale factor is especially useful for best signal-to-noise ratio in experiments involving low energy sources.

The performance of the Model 2006 is the current state of the art for proportional counter preamps. The noise level is equivalent to less than 350 ion pair with zero source capacitance using 2 microseconds near-Gaussian pulse shaping, and degrades less than 1 ion pair per pF of input capacitance. As illustrated in Table 1, low noise and fast risetime prevail over a wide range of input capacitance. The high count rate capability of the design is evidenced by a charge rate capacity greater than 2 x 10^{-7} coulombs per second. In order to take full advantage of such a high count rate capability, a high count rate main shaping amplifier, such as the Canberra Model 2010, is recommended.

A test input is provided on the Model 2006 to assist in system setup. The test capacitor value is certified in the unit test report for reference use as a secondary charge calibration standard. The nominal voltage gain from the test input to the output is x 1 for the output scale factor of 47mV/M ion pair and x 5 for the output scale factor of 235mV/M ion pair.

Power for the 2006 is usually supplied from the associated Canberra pulse shaping amplifier. The power lines are filtered within the unit to provide high noise immunity. A ten foot power cable is provided with the preamp.

DETECTOR INPUT
MODEL 2006
CANBERRA

HV INPUT
OUTPUT
TEST INPUT
MODEL 2006

Specifications

INPUTS

DETECTOR INPUT - Accepts charge pulse from a proportional counter detector, and provides HV bias to the detector.

TEST INPUT - Charge coupled to preamp input @ 3.3 picocoulombs per volt; input impedance is 93 ohms.

HV INPUT - Allows detector bias up to ±5000VDC, detector series bias resistance 110M ohms.

POWER -	+24V	- 24V	+12V	- 12V
	36mA	16mA	2mA	2mA

supplied from associated Canberra main amplifier, or MCA.

OUTPUTS

ENERGY OUTPUT - Inverted tail pulse, risetime as in Table 1, 50µsec fall time constant, up to ±10V; output impedance 93 ohms, direct coupled.

PERFORMANCE

INTEGRAL NONLINEARITY - <±0.02% for up to ±10V, output unterminated.

GAIN DRIFT - <±0.01%/°C (±100ppm/°C).

DETECTOR BIAS ISOLATION - ±5000VDC Maximum.

NOISE OUTPUT PERFORMANCE - See Table 1.

CHARGE SENSITIVITY - 47mV/M ion pair or 235mV/M ion pair, internally selected.

RISE TIME - See Table 1.

CONNECTORS

POWER - Amphenol 17-20090.

DETECTOR INPUT - SHV.

TEST INPUT, ENERGY OUTPUT - BNC.

HV INPUT - SHV.

Ten foot compatible preamplifier power cable with required connectors is supplied with the preamplifier.

PHYSICAL

SIZE - 3 x 4 x 1.75 inches (7.6 x 10.2 x 4.4 cm).

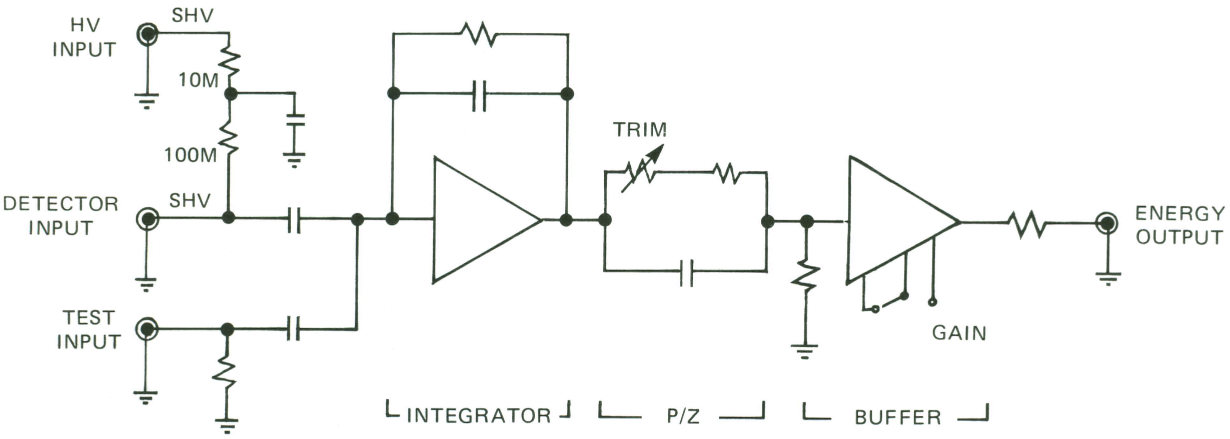
NET WEIGHT - 12 ounces (0.34 kg).

SHIPPING WEIGHT - Approximately 18 ounces (0.5 kg).

TABLE 1

C source in picofarads	**Noise Charge**		**Rise Time in nanoseconds**
	ion pair RMS	**Coulombs RMS**	
0	<350	$<5.6 \times 10^{-17}$	<20
30	<380	$<6.1 \times 10^{-17}$	<20
100	<460	$<7.7 \times 10^{-17}$	<25
300	<660	$<1.2 \times 10^{-16}$	<35

Noise performance measured using Canberra Model 2010 Spectroscopy Amplifier set at 2 microsecond unipolar near-Gaussian shaping.

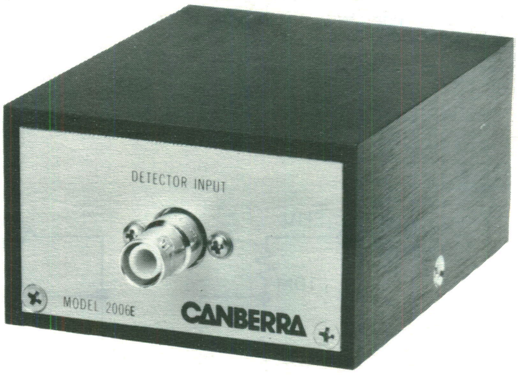

HV INPUT
SHV
10M
100M
DETECTOR INPUT
SHV
TEST INPUT
TRIM
GAIN
ENERGY OUTPUT
INTEGRATOR
P/Z
BUFFER

FUNCTIONAL SCHEMATIC

Model 2006E
Proportional Counter Preamplifier

Features

- Low noise design: less than 450 ion pairs @ $C_S = 0$ pF
- High charge rate capacity (up to 1×10^{-7} coulombs/sec) for high count rate applications
- FET input, diode protected
- Fast risetime: less than 25nsec @ $C_S = 0$ pF
- High voltage operation up to ±5000VDC



HV INPUT
OUTPUT
TEST INPUT
MODEL 2006E

Description

The Canberra Model 2006E represents the latest advance in charge sensitive preamplifiers for use with proportional counter detectors. The preamp converts the ionization charge from the detector into a step voltage pulse whose amplitude is proportional to the total charge collected in each event. The pulse decays with a time constant of 50 microseconds for presentation to a main amplifier.

For typical use with a positive polarity HV bias to the anode of the detector, the preamplifier generates positive polarity energy pulses which are shaped in the amplifier as necessary for counting or low energy X-ray analysis.

The Model 2006E preamplifier contains a diode-protected FET input stage optimized for low noise operation. As shown in the functional schematic the first stage acts as an operational integrator which produces an output potential proportional to the accumulated charge. This integrator configuration is followed by a pole/zero adjustment to return the unipolar pulse to a reference or baseline level without overshoot, and a differentiator to provide the 50 microsecond tail pulse. The second active stage operates as a buffer for driving various cable lengths without pulse degradation. Conversion gains of nominally 47mV/M ion pairs or 235mV/M ion pairs may be selected by a jumper plug on the printed circuit board inside the unit. The high scale factor is especially useful for the best signal-to-noise ratio in experiments involving low energy sources.

The noise level of the Model 2006E is equivalent to less than 450 ion pairs with zero source capacitance using 2 microseconds near-Gaussian pulse shaping, and degrades 1 ion pair per pF of input capacitance. As illustrated in Table 1, low noise and fast risetime prevail over a wide range of input capacitance. The high count rate capability of the design is evidenced by a charge rate capacity greater than 1×10^{-7} coulombs per second. In order to take full advantage of such a high count rate capability, a high count rate main shaping amplifier, such as the Canberra Model 2010, is recommended.

A test input is provided on the Model 2006E to assist in system setup. The test capacitor value is certified in the unit test report for reference use as a secondary charge calibration standard. The nominal voltage gain from the test input to the output is x 1 for the output scale factor of 47mV/M ion pair and x 5 for the output scale factor of 235mV/M ion pair.

Power for the 2006E is usually supplied from the associated Canberra pulse shaping amplifier. The power lines are filtered within the unit to provide high noise immunity. A ten foot power cable is provided with the preamp.

Specifications

INPUTS

DETECTOR INPUT - Accepts charge pulse from a proportional counter detector, and provides HV bias to the detector.

TEST INPUT - Charge coupled to preamp input @ 3.3 picocoulombs per volt; input impedance is 93 ohms.

HV INPUT - Allows detector bias up to ±5000VDC, detector series bias resistance 110M ohms.

POWER -

+24V	-24V	+12V	-12V
36mA	16mA	2mA	2mA

supplied from associated Canberra main amplifier, or MCA.

OUTPUTS

ENERGY OUTPUT - Inverted tail pulse, risetime as in Table 1, 50μsec fall time constant, up to ±10V; output impedance 93 ohms, direct coupled.

PERFORMANCE

INTEGRAL NONLINEARITY - <±0.08% for up to ±10V, output unterminated.

GAIN DRIFT - <±0.02%/°C (±200ppm/°C)

DETECTOR BIAS ISOLATION - ±5000VDC Maximum.

NOISE OUTPUT PERFORMANCE - See Table 1.

CHARGE SENSITIVITY - 47mV/M ion pair or 235mV/M ion pair, internally selected.

RISE TIME - See Table 1.

Specifications(continued)

CONNECTORS

POWER - Amphenol 17-20090.

DETECTOR INPUT - SHV

TEST INPUT, ENERGY OUTPUT - BNC.

HV INPUT - SHV.

Ten foot compatible preamplifier power cable with required connectors is supplied with the preamplifier.

PHYSICAL

SIZE - 3 x 4 x 1.75 inches (7.6 x 10.2 x 4.4 cm).

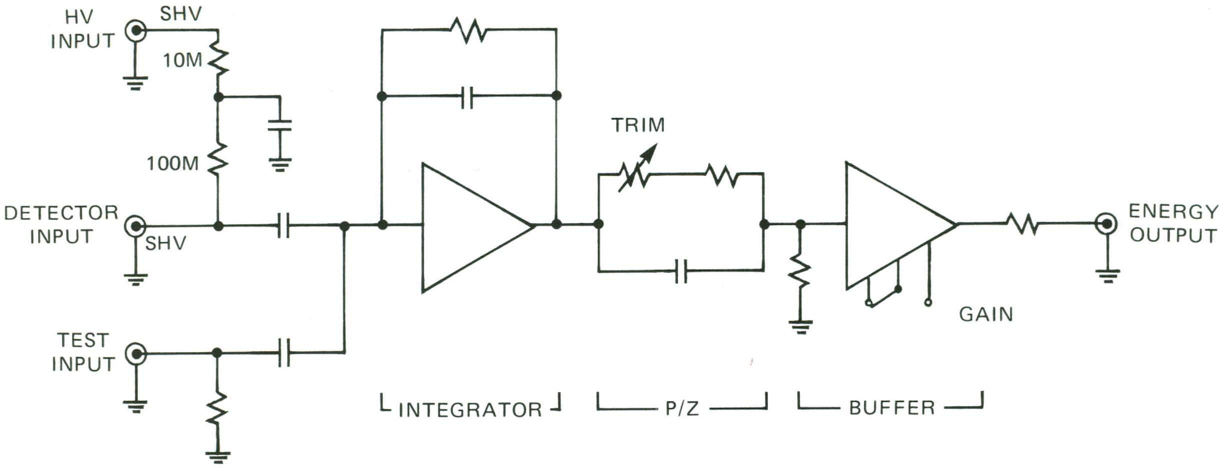
NET WEIGHT - 12 ounces (0.34 kg).

SHIPPING WEIGHT - Approximately 18 ounces (0.5 kg).

TABLE 1.

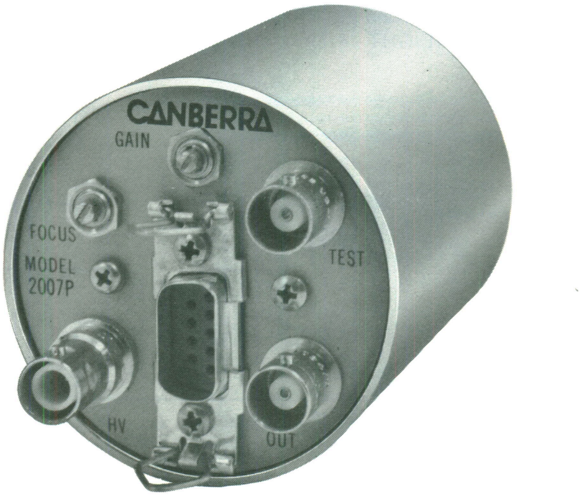
C source in picofarads	**Noise in ion pair RMS**	**Noise in Coulombs RMS**	**Rise Time in nanoseconds**
0	<450	$<7.2 \times 10^{-17}$	<25
30	<490	$<7.8 \times 10^{-17}$	<25
100	<560	$<8.9 \times 10^{-17}$	<30
300	<770	$<1.2 \times 10^{-16}$	<40

Noise performance measured using Canberra Model 2010 Spectroscopy Amplifier set at 2 microsecond unipolar near-Gaussian shaping.


HV INPUT
SHV
10M
100M
DETECTOR INPUT
SHV
TEST INPUT
TRIM
GAIN
ENERGY OUTPUT
INTEGRATOR
P/Z
BUFFER

FUNCTIONAL SCHEMATIC

Model 2007P
PM Tube Base–Preamplifier



Features

- Combination photomultiplier (PM) tube base, voltage divider, and preamplifier in one integral unit
- Low noise, charge sensitive preamplifier with H.V. transient protection
- PMT bias operation to +2kVDC
- Focus and gain controls provided

Description

The Model 2007P consists of a photomultiplier tube base, a voltage divider with separate gain and focus controls, and a charge sensitive preamplifier housed in one compact assembly.

The tube base contains a high voltage divider network to supply all the necessary bias potentials for the most common 10-stage PM tubes used in nuclear experimentation. A gain control permits trimming the high voltage applied to the divider thereby facilitating the matching of a plurality of PMT outputs for array setups, while the focus control provides for optimization of detector resolution.

The preamplifier integrates the charge impulse from the anode of the PM tube for presentation to pulse shaping main amplifiers such as the Canberra Model 2020. The preamp features protection from high voltage transients, noise contribution less than 0.1 femtocoulomb RMS and a rise time of less than 20 nanoseconds.

No additional power supply is required for the preamplifier circuit as the Model 2007P obtains all necessary power directly from the associated main amplifier.

Specifications

INPUTS

DETECTOR SIGNAL - the preamp input is AC coupled internally to the anode through pin 11 of the PM tube socket.

HV - accomodates PM tube bias up to 2kVDC maximum.

TEST - positive or negative tail pulse from test pulse generator; charge coupled at 30 picocoulombs per volt; input impedance 93 ohms.

PREAMP POWER - ±12 volts DC from associated main amplifier through compatible cable provided.

OUTPUTS

PREAMP SIGNAL - inverted tail pulse; rise time less than 20 nanoseconds; fall time, 50 microseconds nominal; up to +10 volts through series connected 93 ohm resistor; direct coupled.

CONTROLS

FOCUS - single turn screwdriver adjustment for optimization of resolution.

GAIN - single turn screwdriver adjustment for trimming HV.

PERFORMANCE

INTEGRAL NONLINEARITY - <±0.04% for up to +10V output.

GAIN DRIFT - <±0.01% per °C (±100ppm/°C)

PM TUBE BIAS ISOLATION - +2000VDC maximum.

NOISE - <0.1 femtocoulomb (10^{-16} coulomb).

CHARGE SENSITIVITY - 4.5 mV/picocoulomb, nominal.

DIVIDER BIAS - total resistance 7.2M ohm nominal; 10 dynodes @ 72V per kVDC of detector bias; anode limiting resistor 560k ohm.

FOCUS CONTROL RANGE - +72V to +145V per kVDC of detector bias.

GAIN CONTROL RANGE - varies total PMT bias from between 92% and 100% of applied high voltage.

CONNECTORS

POWER - Amphenol 17 series.

TEST - BNC.

OUTPUT - BNC.

H.V. - SHV

PM TUBE SOCKET - Cinch-Jones 3M-14

POWER REQUIREMENTS

PREAMP - ±12VDC @ 15mA

HV - 0-2kVDC @ 0-300µADC.

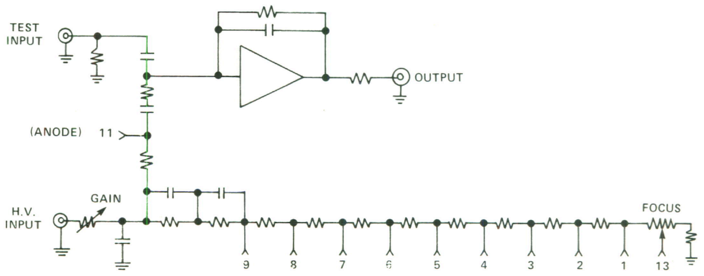
PHYSICAL

DIAMETER - 2.3 in. (5.8 cm).

LENGTH - 3 in. (7.6 cm).

NET WEIGHT - 0.5 lb. (0.2 kg).

SHIPPING WEIGHT - 2.5 lbs. (1.1 kgs).



Amplification is actually the minor role of a nuclear research amplifier. The instrument might best be termed a signal processor. The major role of an amplifier is to convert the preamplifier output signal into a form most suitable for the measurement desired. Since there exists a great number of applications dealing with different characteristics of the input, so are there techniques for treating the signal to optimize each condition.

Some amplifiers are designed to be sufficiently flexible to handle a variety of measurement conditions, while others are tailored to optimize a specific measurement. Common to all amplifiers is the requirement to operate on pulses of information. Fig. 1A illustrates a preamplifier's output signal whose leading edge contains the energy and timing information desired.

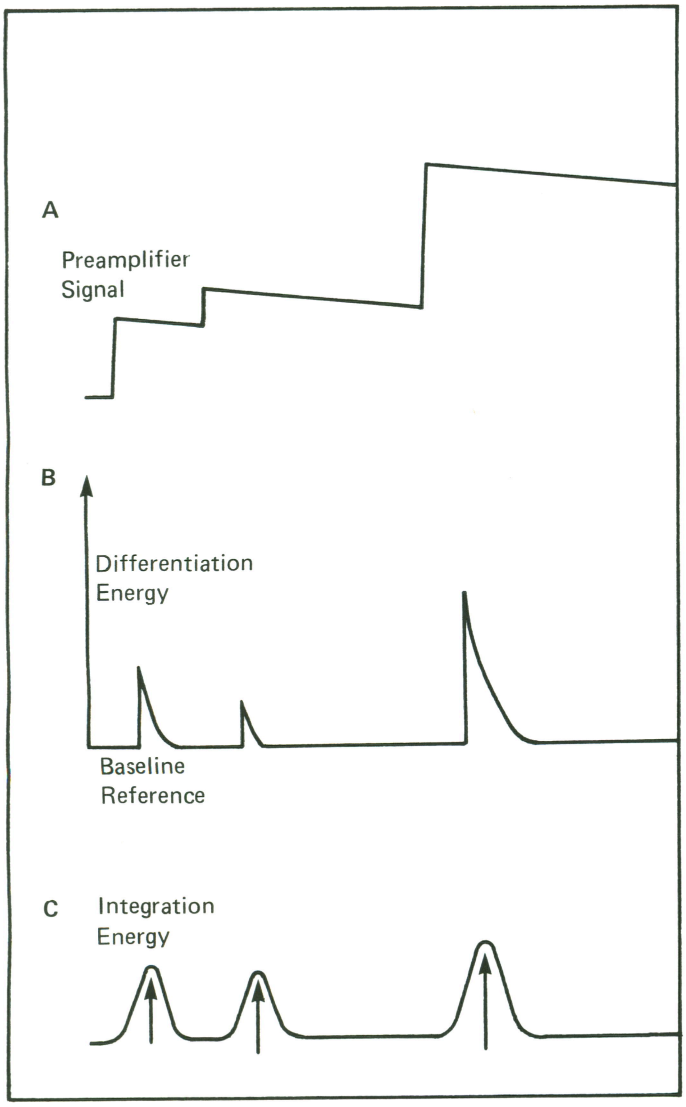


Figure 1

The trailing edge of the preamp signal decays slowly back to the baseline, giving rise to the term, "long-tailed pulse". Since each new pulse will be riding on the tail of the previous pulse, the first job of the amplifier is to restore a baseline reference level for each pulse by differentiation (Fig. 1B). The differentiator is a high pass filter which passes all the information in the fast leading edge of the long tail pulse and sharply clips the slow trailing edge. The design of the differentiator is complicated by the need to insure that the trailing edge is precisely cancelled. A pole/zero cancellation circuit which can be varied to match any standard preamp time constant is included in all quality amplifiers. Pole/zero cancellation prevents under or overshoots from contaminating subsequent pulses.

After differentiation the signal is integrated to recover its information content. In practice, differentiation and integration are performed by filtering selected frequency components from the signal. As this implies, the frequency characteristics of the filters employed must be selected to preserve both the integrity of the information content and maintain the reference between events. At this point compromises arise. If the time constant of the amplifier is shortened to provide a rapid return to the baseline for high count rate work, it degrades signal quality by allowing too much noise through the amplifier. Conversely, if the integration time constant is lengthened to improve resolution, the resultant pulse becomes wider, introducing the possibility of baseline shift as events pile up on one another.

Using simple RC (resistor - capacitor) filters, the point of compromise is reached quite early. Active filtering, however, allows us to tailor the frequency response of the networks. By achieving a near Gaussian pulse shape, through selective active filtering, a dramatic improvement over RC filtering in Signal to Noise and count rate performance is achieved.

The pulse shaping method that provides optimum Signal-to-Noise enhancement while maintaining the timing aspect is the Gaussian shaping provided in Canberra's spectroscopy amplifiers. This technique involves one pulse differentiation followed by several stages of active integrator filtering, all set to the same cutoff frequency (the shaping time constant). The instrument thus becomes a narrow bandpass filter-amplifier.

In segregating successive energy pulses with any shaping method, another factor must be correctly treated for best amplifier performance: baseline stabilization. Baseline stabilization normalizes the unipolar output pulse to a D.C. reference (usually 0 V.D.C.) to assure that successive pulses may be precisely quantized in subsequent instruments. This process involves clamping of negative (e.g.) signal pulses and, properly executed, a means of fast clipping the exponential tail of the Gaussian shaped output back to the baseline. The full process is more properly termed baseline restoration, and the effectiveness of an amplifier's baseline restorer determines its utility in high count rate spectra.

The largest single tradeoff in amplifier design is complexity versus cost. The complexity issue involves both the plurality of features such as number of shaping time constants available and the number of active complex pole pair integrators which refine the Gaussian waveshape, and the choice of symmetrical and/or asymmetrical baseline restorer circuits, prompt and delayed outputs, etc. The Canberra amplifier product line offers spectroscopy grade performance with easily identified user options on complexity-cost tradeoffs.

To provide the user with the highest level of performance at each price level, Canberra spectroscopy amplifiers offer active filter Gaussian shaping and a gated baseline restorer for the unipolar output. Noise levels are among the lowest available, and have been carefully treated to have a minimum effect in even the highest resolution experiments.

The Canberra Model 2020 Spectroscopy Amplifier offers the user a level of flexibility second to none. Wide gain range (3-3900), large number of shapings (12), restorer with selectable symmetry and a Pile Up Rejector with Live Time Correction (PUR/LTC) are just a few of the key features designed into the instrument. This means that the 2020 can, in most cases, give optimal results for all types of detectors up to very high count rates. The unit has proved effective at up to 200,000 counts per second with Cobalt-60.

For those who require the same high performance the 2020 provides, but at low to medium count rates, the Canberra Model 2021 comes without a PUR/LTC. Both the 2020 and the 2021 offer unipolar (prompt or delayed) and bipolar output.

Simplifying the options, the Canberra Model 2011 offers 4 shaping time constants, a wide gain range, a full time gated baseline restorer, and both unipolar (prompt and delayed) and bipolar outputs.

The new Model 2012 provides utility performance with 2 shaping time constants, wide gain range, and a single unipolar output with a full time symmetrical gated baseline restorer.

Two other specialty amplifier products warrant comment. The Model 2015A offers the utility amplifier of the Model 2012 in conjunction with a built-in timing single channel analyzer. For many simpler coincidence experiments, the timing variance (walk) of the instrument is fully adequate. Alternately the user may wish to use the normal SCA output in conjunction with the optional (internally selected) ULD or LLD output for energy discrimination. The SCA features excellent stability (±50ppm/°C) over a wide dynamic range.

Canberra offers the Model 814 combination preamplifier, amplifier and discriminator as a low-cost unit. This unit offers good performance at a low cost for scintillation and G.M. detector applications.

In a delay line amplifier the preamplifier signal is inverted and delayed through the delay line, then added to the original. The output is therefore cancelled after the rising edge signal has passed. A double delay amplifier repeats the process, resulting in a bipolar output. Since the rising edge is passed without modification and the baseline is achieved rapidly, the delay line amplifier finds its greatest use in timing and high count rate measurements. (Fig. 2)

The Model 1411A double delay line amplifier finds frequent application in scintillation work where the double delay line (DDL) output provides an optimum signal for high level timing analysis in the crossover mode. The DDL output provides the fastest possible counting rate available in an amplifier, with excellent overload recovery.

Canberra's line of amplifiers is optimized to provide the maximum in performance without sacrificing convenience of operation or stable, trouble free operation.

You will find them particularly convenient to interface to other system components and flexible in application. The Canberra Amplifier Preview Chart will assist you in selecting the instrument best suited to your requirements.

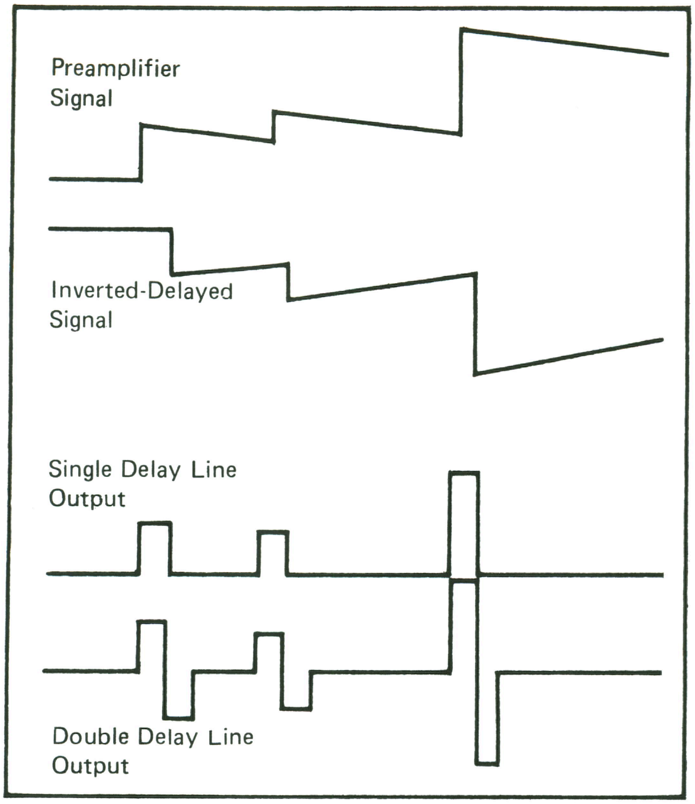
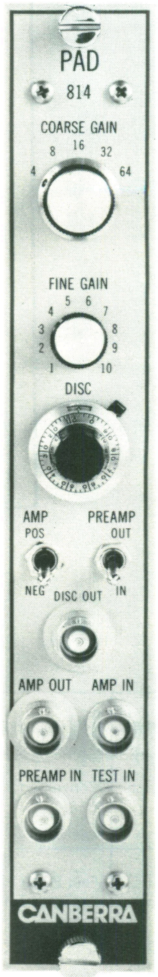


Figure 2

CANBERRA AMPLIFIER PREVIEW CHART

APPLICATION/DETECTOR TYPE	USER BENEFIT	KEY FEATURES	DESCRIPTION AND MODEL
Scintillation, G.M. & Proportional Counter Detectors	Convenience & Low Cost	PAD in 1 Wide Nim Discriminator & Bipolar Amp Outputs	Preamp/Amp/Discriminator 814
Very High Count Rate and Timing Applications	Fast Pulse Processing Accurate Timing Results	Rapid Return to Baseline Minimal Time Jitter	Double Delay Line Amp 1411A
X-Ray Diffraction & Florescence	Minimal Count Loss @ High Rates Convenience	Fast Pulse Processing Combination Amp/PHA in a Single NIM Width	X-Ray Amp/Pulse Height Analyzer 1718
General Purpose Spectroscopy	Excellent Features & Performance Moderate Cost	Single Width, Unipolar & Bipolar Outputs	Spectroscopy Amplifier 2011
Scintillation, Gas Proportional & SSB Detectors/Alpha Spec.	Excellent Performance at Low Cost	Unipolar Output, Single Width Two Shaping Time Constants	Spectroscopy Amplifier 2012
Pulse Height Analysis and Coincidence Applications	High Performance & Convenience	Amp/TSCA in Single Width NIM	AMP/TSCA 2015A
Highest Resolution Spectroscopy High Count Rate Spectroscopy For Use With All Detectors	Stable Results with Varying Count Rates Accurate Results at High Count Rates Optimal Detector Matching	Combination AMP/PUR/LTC Twelve Shaping Time Constants	Spectroscopy Amplifier 2020
Highest Resolution Spectroscopy For Use With All Detectors	Highest Resolution for Lo Medium Count Rates Optimal Detector Matching	Highest Performance without PUR/LTC Twelve Shaping Time Constants	Spectroscopy Amplifier 2021

Model 814
Preamp/Amp/Disc



Features

- Wide range of signal input selection
- Discriminator dynamic range 200:1
- Ideal for scintillation and gas proportional detectors

Description

The Canberra Model 814 contains a charge sensitive bipolar transistor input preamplifier, a linear amplifier with a maximum gain of 600 and an integral discriminator. It accepts the positive or negative charge output of scintillation detectors or gas proportional counters, and provides, at the AMP OUT connector, a near-Gaussian bipolar output pulse.

Amplifier gain is established by front panel controls; a five position switch provides a 16:1 range in 2:1 steps; a front panel single-turn continuous control provides a 3:1 fine gain range.

The module can accept either a positive or negative preamplifier (or amplifier) input signal by use of a front panel polarity selection switch. An integral discriminator provides a positive eight volt rectangular pulse at the DISC OUT connector for each amplifier output when it exceeds a selected threshold. The amplifier output can be obtained separately. Discriminator threshold is selected by a ten-turn locking dial front panel control and spans a range from 50 millivolts to 10 volts.

Specifications

INPUTS

PREAMP IN - front panel BNC connector which accepts negative or positive charge signals from gas proportional counters or scintillation counters; input sensitivity, 3.3mV/picocoulomb.

AMP IN - front panel BNC connector which accepts negative or positive tail pulses from an external preamplifier.

TEST IN - front panel BNC connector, used to check sensitivity and noise calibration of module; test capacitance, 1pf nominal.

OUTPUTS

DISC OUT - front panel BNC connector which provides a pulse each time the amplifier output exceeds the discriminator threshold setting; polarity, positive; eight volts amplitude; $Z_O \approx 10$ ohms.

AMP OUT - front panel BNC connector; positive lobe leading, near-Gaussian pulse; up to 10 volts amplitude; output impedance $\leqslant 1$ ohm.

CONTROLS

COARSE GAIN - front panel rotary switch, 16:1 range in 5 binary steps.

FINE GAIN - front panel single-turn potentiometer; range of 1:1/3 of output selected.

DISCriminator - front panel ten-turn locking dial potentiometer selects the threshold level for the DISC OUTput; can be adjusted for sensitivities from 50 millivolts to 10 volts.

AMP POS/NEG - front panel two-position switch; sets the polarity which will be accepted at the AMP or PREAMP inputs.

PREAMP IN/OUT - front panel two-position toggle switch; connects or disconnects the internal preamplifier from the amplifier.

PERFORMANCE

PREAMP AND AMPLIFIER

GAIN DRIFT - $\leqslant 0.005\%/^{\circ}C$.

PULSE SHAPING - 1.25 microsecond time constant; near-Gaussian bipolar.

AMP OUTPUT - ± 10.0 volts, integral nonlinearity $\leqslant \pm 0.5\%$ from 0.10 to 10 volts; $Z_O \leqslant 1$ ohm.

DISCRIMINATOR

SENSITIVITY - 50 millivolts to 10 volts, selected by front panel ten-turn potentiometer.

NONLINEARITY - $\leqslant \pm 0.5\%$, 50 millivolts to 10 volts.

TEMPERATURE DRIFT - $\approx 5mV/^{\circ}C$.

OUTPUT IMPEDANCE - ≈ 10 ohms.

PULSE SHAPE - 1 microsecond rectangular pulse; rise time of 50 nanoseconds; positive polarity; amplitude, 8 volts.

OPERATING TEMPERATURE RANGE - 0 to 50°C.

CONNECTORS

All signal connectors are BNC type.

POWER

+24V	—	30mA	+12V	—	75mA
- 24V	—	25mA	- 12V	—	60mA

PHYSICAL

SIZE - standard single-width module (1.35 x 8.71 inches) (3.42 x 22.13 cm) per TID-20893 (rev.)

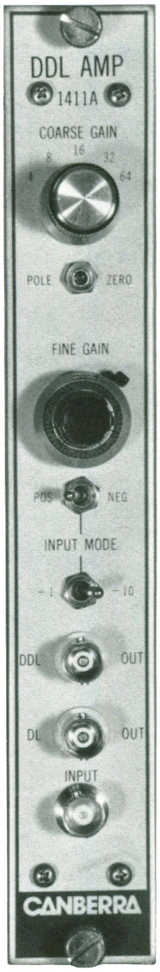
NET WEIGHT - 1.4 lbs. (0.63 kgs.).

SHIPPING WEIGHT - 3.0 lbs. (1.4 kgs.).

Model 1411A
Double Delay Line Amplifier

Features

- Optimum High Counting Rate Performance
- Accurate Timing Capabilities
- Prompt and Delayed Outputs
- Excellent Overload Recovery
- Less than 10 μvolts Noise at Full Gain



Description

The Canberra Model 1411A Double Delay Line Amplifier accepts the preamplified positive or negative output signals from proportional counters, scintillation detectors or semiconductor detectors. It yields output signals suitable for single channel or multichannel analysis, and for leading edge or zero crossing timing.

The DDL Amplifier is especially well suited for applications requiring:

*High counting rates, as DDL shaping offers the most rapid baseline recovery

*Heavy overload conditions, as DDL shaping yields unsurpassed overload performance

*The most accurate leading edge or zero crossing timing over a wide dynamic range, as DDL shaping exhibits minimum timing jitter when compared to alternative shaping approaches

When these requirements are not present, DDL shaping is not recommended, as it has the disadvantage of slightly greater inherent amplifier noise than the classical RC shaping, or active-filter networks, leading to loss of system resolution.

The Model 1411A has been designed to optimize its performance in those applications for which DDL shaping is best suited. It offers adjustable Pole/Zero cancellation to optimize baseline recovery and maximize overload performance. The Model 1411A will recover from a 500x overload in less than 2.5 microseconds when using 0.4 microsecond delay lines.

The Model 1411A exhibits less than one nanosecond of crossover walk over a 20:1 dynamic range (0.5 to 10 volt output). It is thus unmatched when precise fast coincidence timing using the zero crossing technique is desired. The Model 1411A DDL Amplifier offers both prompt (DDL OUT) and delayed (DL OUT) signals, to preserve a unipolar signal for energy analysis after timing and coincidence evaluation has taken place. The unipolar (DL) signal has an integration time constant of 700 nanoseconds (with 1 microsecond delay lines) for optimum energy analysis.

Specifications

INPUTS

INPUT - positive or negative tail pulse from associated preamplifier; 0 to 5 volts, 0 - 1000 nanosecond rise time, 5 μsec to ∞ fall time constant; input impedance 1k ohms; dc coupled; front panel BNC connector.

OUTPUTS

DDL OUT - bipolar (positive lobe leading), 0 - 10 volts, 10.5 volts saturation into 93 ohms; double delay line clipped, rise time less than 100 nanoseconds, width per lobe 1.0 microsecond (0.2, 0.4, 0.6, 0.8 microseconds optional); output impedance less than 1 ohm; dc coupled; front panel BNC connector.

DL OUT - positive unipolar 0 - 10 volts, 10.5 volts saturation; single delay line clipped, rise time approximately 700 nanoseconds for optimum energy analysis; delayed from DDL OUT by 2.5 microseconds; output impedance less than 1 ohm; dc coupled; front panel BNC connector.

PERFORMANCE

GAIN STABILITY - better than 0.01%/°C, better than 0.02% over 24 hours with constant temperature and supply voltages.

LINEARITY - better than 0.1% integral from 0.3 to 10 volts output.

OVERLOAD RECOVERY - recovers to within 2% of baseline from 500x overload in less than 2 nonoverloaded pulse widths, at full gain.

DC LEVEL STABILITY - better than 2 mV/°C, better than 10 mV over 24 hours.

CROSSOVER WALK - less than 1 nanosecond crossover jitter over a 20:1 output amplitude range (0.5 - 10 volts).

NOISE - less than 10 microvolts referred to the input, at full gain (DL output).

GAIN - maximum gain 1000; adjustable via front panel controls over 640:1 range.

CONTROLS

COARSE GAIN - front panel rotary switch, 16:1 range in five binary steps.

FINE GAIN - front panel single-turn precision potentiometer, 4:1 range.

Specifications(continued)

POLE ZERO - front panel screwdriver adjustment to optimize amplifier baseline recovery and overload for the preamplifier fall time constant used; Range, 5 μsec to ∞ preamp fall time constants.

INPUT POLARITY - front panel toggle switch, POS and NEG positions.

INPUT MODE - front panel toggle switch, ÷1 and ÷10 positions.

DC LEVELS - two internal adjustments to set output dc levels to zero volts.

CONNECTORS

INPUT - BNC.

OUTPUTS - two, BNC.

PREAMPLIFIER POWER - Amphenol 17-10090, rear panel.

POWER

+24 V — 70 mA	+12 V — 25 mA
- 24 V — 65 mA	- 12 V — 30 mA

PHYSICAL

SIZE - standard single width NIM module, 3.4 x 22.1 cm (1.35 x 8.714 in.) per TID-20893 (rev.).

NET WEIGHT - 1.3 kg (2.8 lb).

SHIPPING WEIGHT - 1.8 kg (4 lb).

Model 2022
Spectroscopy Amplifier

Features

- 6 front panel selectable shaping time constants
- Noise $\leqslant 4.0\mu V$ RMS referred to input at gain $\geqslant 100$ and $2\mu sec$ shaping
- DC drift $\leqslant \pm 10\mu V/°C$
- Unique active baseline restorer for optimum resolution performance

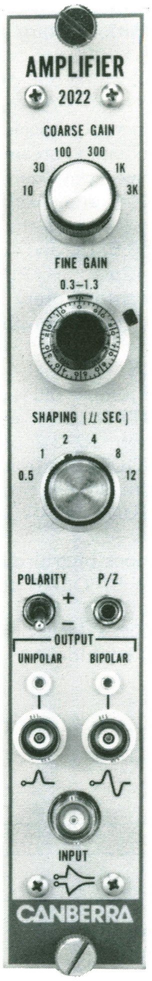
Description

The Canberra Model 2022 Amplifier offers the resolution performance of Canberra's popular Model 2021 Spectroscopy Amplifier in a single width NIM module. Canberra's well known filter shaping provides improved pulse symmetry, minimum sensitivity of output amplitude to variation in detector rise time, and maximum signal to noise ratio. Unipolar shaping is achieved with one differentiator and two active filter integrators. The differentiator is placed early in the amplifier to insure good overload recovery. The integrators are placed late to minimize noise contribution from the gain stages. The amplifier offers 6 front panel selectable pulse SHAPING time constants of 0.5, 1, 2, 4, 8 and 12μsec.

The Model 2022 also employs Canberra's unique active baseline restorer for optimum performance with high resolution detector systems. The gated baseline restorer automatically adjusts the restoration rate to the incoming count rate. It also restores in an asymmetrical manner to virtually eliminate charge accumulation and correlated noise on the restorer holding capacitor.

Simultaneous UNIPOLAR and BIPOLAR outputs are available at both front and rear panel BNC connectors. The unipolar signal can be delayed by 2μsec with option 2022-2 or by 4μsec with option 2022-4. The bipolar output can be used for counting, timing or gating.

The Model 2022 borrows the Model 2021's DC stability and low noise to provide a high performance spectroscopy amplifier in a single width NIM module.



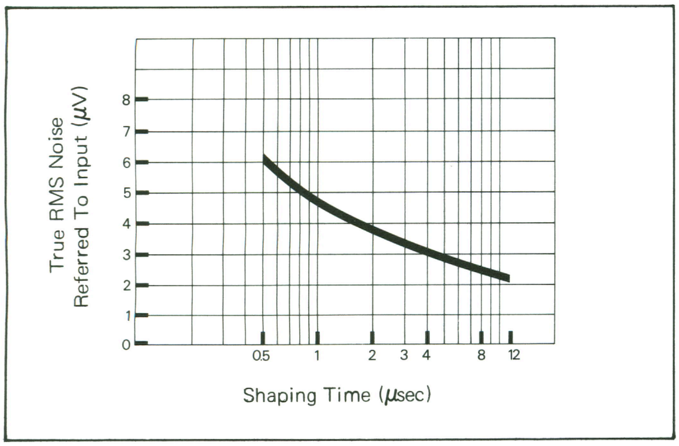


Figure 1.
Typical Model 2022 Unipolar Output True RMS Noise (referred to input for gain of 100) vs. Shaping Time Constant.

Specifications

INPUTS

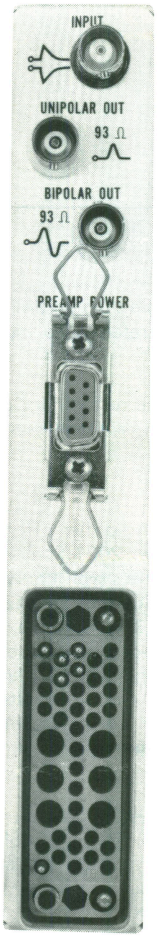
INPUT - accepts positive or negative pulses from an associated preamplifier; amplitude: ±10 volts ÷ selected gain, ±12 volts maximum; rise time: less than SHAPING time constant; decay time constant: 40μsec to ∞ for 0.5, 1, 2, and 4μsec shaping time constants, 100μsec to ∞ for 8 and 12μsec shaping time constants; input impedance: ≃1K ohms; input BNC connectors located on front and rear panel.

OUTPUTS

UNIPOLAR OUTPUT - provides positive linear active filter near-Gaussian shaped pulses; amplitude linear to +10 volts, 12 volts max.; D.C. restored; output D.C. level factory calibrated to 0±5mV; front panel output impedance less than 1 ohm or ≃ 93 ohms internally selectable; rear panel output impedance ≃93 ohms; short circuit protected; prompt or delayed 2μsec with option 2022-2 or 4μsec with option 2022-4; BNC connectors located on front and rear panels.

Specifications(continued)

BIPOLAR OUTPUT - provides prompt positive lobe leading linear active filter bipolar shaped pulses; amplitude linear to +10 volts, 12 max., negative lobe is approximately 70% of positive lobe; D.C. coupled; output D.C. level ±25mV; front panel output impedance less than 1 ohm or ≃93 ohms, internally selectable; rear panel output impedance ≃93 ohms; short circuit protected; BNC connectors located on front and rear panels.



FRONT PANEL CONTROLS

COARSE GAIN - 6 position rotary switch selects gain factors of X10, X30, X100, X300, X1000 and X3000.

FINE GAIN - ten-turn locking dial precision potentiometer selects variable gain factor of X0.3 to X1.3 resetability ≤ 0.03%.

INPUT POLARITY - 2 position toggle switch to set the Model 2022 for the polarity of the incoming preamplifier signal.

P/Z - 22-turn screwdriver pole zero potentiometer to optimize amplifier baseline recovery and overload performance for the preamplifier fall time constant and the Model 2022's pulse shaping chosen; 40µsec to ∞ for 0.5, 1, 2 and 4µsec SHAPING time constants. 100µsec to ∞ for 8 and 12µsec SHAPING time constants.

SHAPING TIME - 6 position rotary switch; provides 0.5, 1, 2, 4, 8 and 12µsec basic shaping time constants.

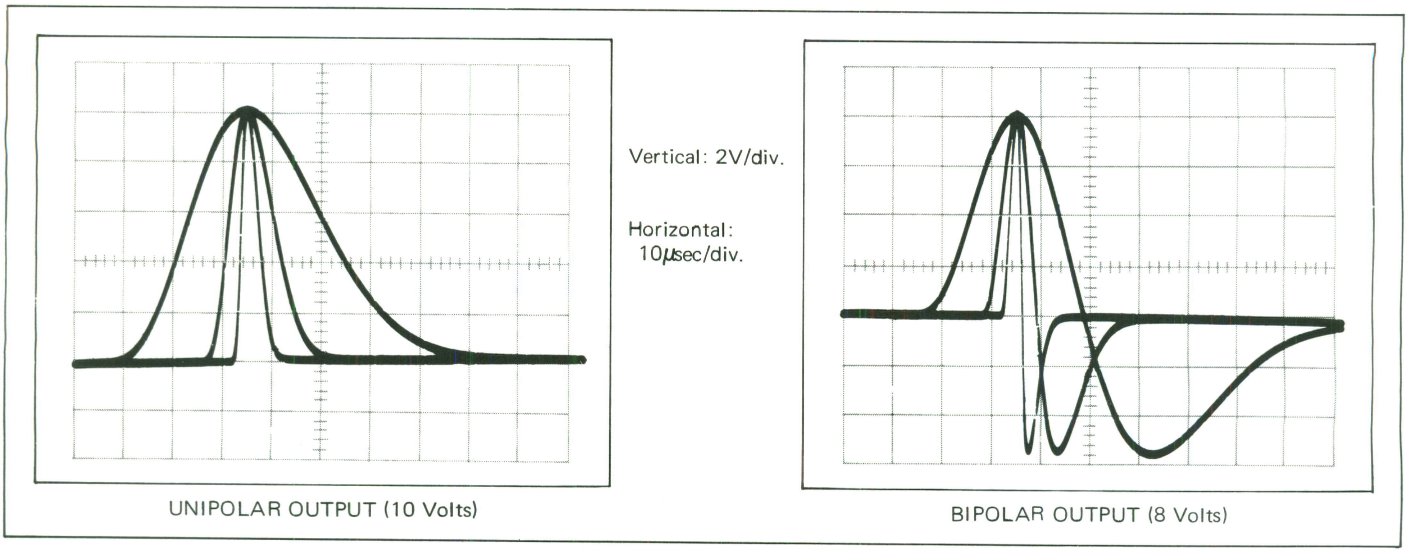
INTERNAL CONTROLS

UNIPOLAR DELAY - 2 jumper plugs provided to select UNIPOLAR output for prompt (OUT) or optional delay (IN). Delay selected for either 2µsec with option 2022-2 or 4µsec with option 2022-4. Shipped in the prompt (OUT) position.

UNIPOLAR Z_{OUT} - jumper plug provides Z_{OUT} ≤1 ohm or ≃93 ohms for the front panel UNIPOLAR output. Shipped in the ≤1 ohm position.

BIPOLAR Z_{OUT} - jumper plug provides Z_{OUT} ≤1 ohm or ≃93 ohms for the front panel BIPOLAR output. Shipped in the ≤1 ohm position.

L/E - jumper plug J7 selects a linear or exponential restorer response. Shipped in the L (linear) position.



UNIPOLAR OUTPUT (10 Volts)

BIPOLAR OUTPUT (8 Volts)

Figure 2.
Model 2022 SHAPING selected for 12, 4, and 1µsec.

Specifications(continued)

PERFORMANCE

GAIN RANGE - continuously variable from X3 to X3900, product of COARSE and FINE GAIN controls.

OPERATING TEMPERATURE RANGE - 0 to 50°C.

GAIN DRIFT ⩽ ±0.0075%/°C.

DC LEVEL DRIFT - UNIPOLAR output ⩽ ±10μV/°C; BIPOLAR OUTPUT: ⩽ ±50μV/°C.

INTEGRAL NON-LINEARITY - ⩽ ±0.05%, over total output range for 2μsec shaping.

CROSSOVER WALK - BIPOLAR output: ⩽ ±3nsec for 50:1 dynamic range and 2μsec shaping when used with Canberra Model 2037A Edge/Crossover Timing Single Channel Analyzer.

OVERLOAD RECOVERY - UNIPOLAR (BIPOLAR) output recovery to within ±2% (1%) of full scale output from X1000 overload in 2.5 (2.0) non-overloaded pulse widths, at full gain, any shaping time constant and pole-zero cancellation properly set.

NOISE CONTRIBUTION - ⩽ 4.0μV true RMS UNIPOLAR (7.1μV BIPOLAR) output referred to input, 2μsec shaping and amplifier gain ⩾ 100.

PULSE SHAPING - near-Gaussian shape: one differentiator (two for bipolar), two active filter integrators; UNIPOLAR time to peak: 2.35X shaping time; pulse width: 7.3X shaping time; BIPOLAR time to cross over: 2.8X shaping time, time to peak, pulse width and crossover times measured at 0.1% of full scale output; 1μsec SHAPING center frequency: 150kHz; band width: 180kHz; f_C and BW for other shaping are multiples of that given for 1μsec.

RESTORER - active gated.

***SPECTRUM BROADENING** - the FWHM of a Co-60 1.33MeV gamma peak for an incoming rate of 2kcps to 100kcps and a 9 volt pulse height will typically change less than 14% for 2μsec shaping.

COUNT RATE STABILITY - the peak position of a Co-60 1.33MeV gamma peak for an incoming count rate of 2kcps to 100kcps and 9 volt pulse height will typically shift less than 0.024% for 2μsec shaping.

*Note: These results may not be reproducible if associated detector exhibits an inordinate amount of long rise time signals.

POWER REQUIREMENTS

+24V dc — 110mA
−24V dc — 145mA
+12V dc — 65mA
−12V dc — 60mA

CONNECTORS

All signal connectors are BNC type.

PREAMP POWER - rear panel, Amphenol, type 17-10070.

PHYSICAL

SIZE - standard single width NIM module 1.35 x 8.71 inches (3.43 x 22.12cm) per TID-20893 (rev.).

NET WEIGHT - 2.9 lbs. (1.3kgs).

SHIPPING WEIGHT - 5.0 lbs. (2.3kgs).

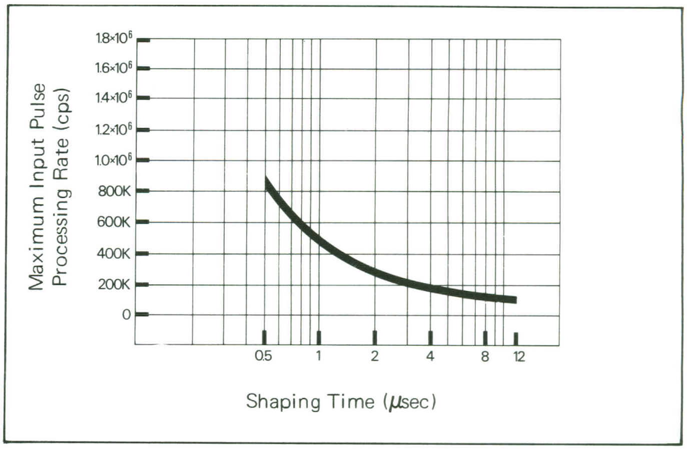


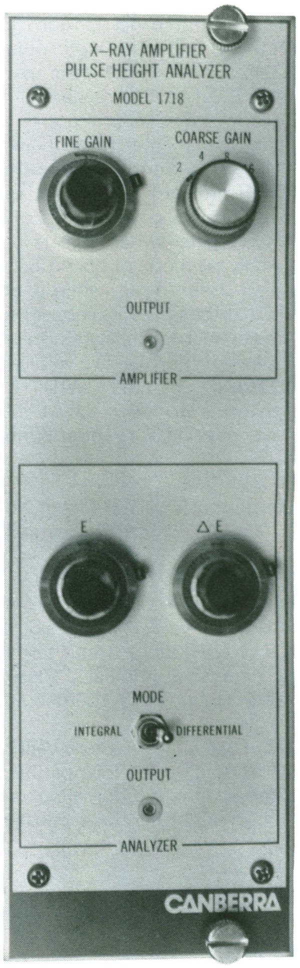
Figure 3.
Typical Model 2022 Maximum Input Pulse Processing Rate verses shaping time constant.

*Maximum Input Pulse Processing Rate: Maximum amplifier input count rate (pulses per second) for which the amplifier's DC restorer maintains the baseline at referenced ground.

Model 1718
X-Ray Amplifier/Pulse Height Analyzer

Features

- Combination Amplifier and PHA
- Delay line pulse shaping for high count rate capability
- Count loss <1% up to 50K cts/sec input rate
- Programmable PHA discriminators
- Simplicity of controls and operation



Description

The Canberra Model 1718 contains an amplifier and pulse height analyzer for use with gas proportional counters or scintillation detectors. Unprecedented count rate stability is achieved when the modular instrument is employed in applications such as X-ray diffraction involving wide variations in count rate. With a pulse pair resolution of 200 nanoseconds, the 1718 will accept input rates of 50,000 cts/sec with less than 1% counting loss due to pulse pileup.

The amplifier features a wide gain range for accepting pulses of either polarity from a preamplifier or directly from a detector. Front panel COARSE and FINE GAIN controls provide continuously adjustable amplifier gain selection from X60 to X1200 with excellent temperature stability. Internally fixed pole/zero cancellation circuitry optimizes amplifier baseline recovery and overload performance for preamplifier decay time constant of 50 microseconds (compatible with all Canberra preamplifiers). Delay line pulse shaping in the amplifier makes short resolving time possible while maintaining low noise contribution. The AMPLIFIER OUTPUT furnishes positive unipolar delay line shaped pulses which are externally connected to the ANALYZER INPUT on the rear panel via a BNC cable supplied with the module. The fast AMPLIFIER OUTPUT is intended to drive SCA's and counters, not MCA's.

The pulse height analyzer section of the Model 1718 performs energy discrimination on the AMPLIFIER OUTPUT pulses in DIFFERENTIAL or INTEGRAL mode of operation. Two front panel ten-turn discriminator controls, identified as E and Δ E, select lower and upper threshold levels by which incoming pulses are passed or rejected based on their pulse height. In DIFFERENTIAL mode an ANALYZER OUTPUT occurs for every input pulse amplitude greater than the E dial setting (0.1 to 10V range) but less than the sum of E plus Δ E (0 to 10V range) settings. INTEGRAL mode disables the Δ E control and generates an ANALYZER OUTPUT for every input signal exceeding the E control setting. The ANALYZER OUTPUT provides a positive 4 volt logic pulse whose width is internally adjustable from 50 to 500 nanoseconds. Rear panel provision is made for remote voltage programming of analyzer E and/or Δ E discriminators in automated applications. When externally controlled, both discriminators are referenced to ground. The ANALYZER INPUT features a DC restorer to allow stable narrow window width (Δ E) operation at high count rates.

An automatic gain stabilized X-ray system can be assembled by inserting a Canberra Model 2050 X-Ray Stabilizer between the Model 1718 AMPLIFIER OUTPUT and the ANALYZER INPUT. The Model 2050's completely solid-state design enables extremely rapid gain correction for abrupt gain changes occurring within any preceding system element.

Specifications

INPUTS

SIGNAL INPUT - accepts positive or negative linear pulses directly or indirectly (preamplifier) from gas proportional counters or scintillation detectors. ±5V maximum; rise time ⩽100nsec; pole/zero cancellation for 50μsec preamplifier decay time constant; Z_{in} ≈1K ohms, DC coupled, rear panel BNC connector.

ANALYZER INPUT - accepts positive unipolar 110nsec delay-line pulses from Model 1718 AMPLIFIER OUTPUT 0.1 to 10V amplitude, 12 volts max; Z_{in} ⩾1K ohms, DC restorer coupled, rear panel BNC connector.

LOWER LEVEL INPUT - accepts positive 0 to 10V DC voltage to permit external control of the analyzer E discriminator; Z_{in} ⩾5K ohms, DC coupled, rear panel BNC connector.

UPPER LEVEL INPUT - accepts positive 0 to 10V DC voltage to permit external control of the analyzer Δ E discriminator; Z_{in} ⩾5K ohms, DC coupled, rear panel BNC connector.

OUTPUTS

AMPLIFIER OUTPUT - provides positive unipolar 110nsec delay line pulses; 0 to 10V amplitude; rise time ⩽60nsec; Z_o ≈93 ohms series-connected, DC coupled, rear panel BNC connector and front panel test point.

ANALYZER OUTPUT - provides positive logic pulse; ≈+4V unterminated, ≈2V into 50 ohms load; width internally adjustable from 50 to 500nsec (shipped with 50nsec pulse width); rise and fall time ⩽25nsec; delayed nominal 100nsec after peak of AMPLIFIER OUTPUT; Z_o ≈50 ohms, short-circuit protected, DC coupled, rear panel BNC connector and front panel test point.

Specifications(continued)

CONTROLS

X-RAY AMPLIFIER

COARSE GAIN - front panel four-position rotary switch to select coarse gain factor of 2, 4, 8, or 16, multiplied by FINE GAIN control setting.

FINE GAIN - front panel ten-turn locking dial precision potentiometer, 3:1 range.

SIGNAL - rear panel toggle switch selects either POSitive or NEGative position to match input signal polarity.

PULSE HEIGHT ANALYZER

E (LOWER LEVEL) - front panel ten-turn locking dial precision potentiometer selects the minimum input pulse amplitude that will generate an ANALYZER OUTPUT (rear panel LOWER LEVEL switch in INT position); 0.1 to 10V range.

Δ E (UPPER LEVEL) - front panel ten-turn locking dial precision potentiometer selects incremental range (window width) of input pulse amplitude above E control setting that will produce an ANALYZER OUTPUT in DIFFERENTIAL mode only (rear panel UPPER LEVEL switch in INT position); 0 to 10V range.

MODE - front panel toggle switch selects either INTEGRAL or DIFFERENTIAL Analyzer mode of operation.

LOWER LEVEL - rear panel toggle switch to enable either INTernal (E control) or EXTernal (positive DC voltage) setting of E.

UPPER LEVEL - rear panel toggle switch to enable either INTernal (Δ E control) or EXTernal (positive DC voltage) setting of Δ E.

ANALYZER OUTPUT PULSE WIDTH - internal trim potentiometer adjustment to vary ANALYZER OUTPUT pulse width, 50 to 500nsec range (factory set at 50nsec width).

PERFORMANCE

X-RAY AMPLIFIER

GAIN RANGE - continuously variable from X60 to X1200, product of COARSE and FINE GAIN controls; resetability $\leqslant$0.1%.

GAIN DRIFT - $\leqslant\pm0.05\%/^{\circ}$C, 0 to 50°C.

DC LEVEL DRIFT - $\leqslant\pm2$mV/$^{\circ}$C, 0 to 50°C.

INTEGRAL NONLINEARITY - $\leqslant\pm0.5\%$ from 0.1 to 10V.

NOISE CONTRIBUTION - $<20\mu$V RMS referred to input at maximum gain, POS or NEG input (Input terminated 93 ohms).

PULSE SHAPING - positive unipolar 110nsec delay-line network with added integration; lobe width 150nsec at 25% height; time to peak = 100nsec.

POLE/ZERO CANCELLATION - factory calibrated for preamplifier decay time constant of 50μsec (compatible with any Canberra preamplifier); optimizes amplifier baseline recovery and overload performance for the preamplifier time constant and the amplifier pulse shaping.

PULSE HEIGHT ANALYZER

E RANGE - positive 0.1 to 10V.

Δ E RANGE - positive 0 to 10V.

INTEGRAL NONLINEARITY - $\leqslant\pm0.5\%$ of full scale for both E and Δ E discriminators.

TEMPERATURE DRIFT - $\leqslant\pm3$mV/$^{\circ}$C for both E and Δ E discriminators.

PULSE PAIR RESOLUTION - $<$200nsec with Model 1718 amplifier and ANALYZER OUTPUT width of 50nsec and E (Lower Level) set at 25% of input signal amplitude.

CONNECTORS

All signal connectors are rear panel mounted BNC type.

PREAMP POWER - rear panel, Amphenol 17-10090.

POWER REQUIREMENTS

+24VDC	— 65mA	+12VDC	— 140mA
- 24VDC	— 55mA	- 12VDC	— 60mA

PHYSICAL

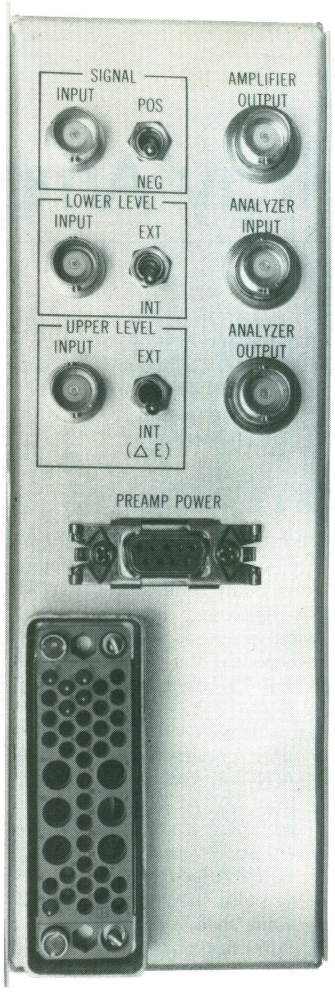
SIZE - standard double-width NIM module, 2.70 x 8.71 inches (6.86 x 22.13 cm) per TID-20893 (rev).

NET WEIGHT - 2.8 lbs. (1.3 kgs.)

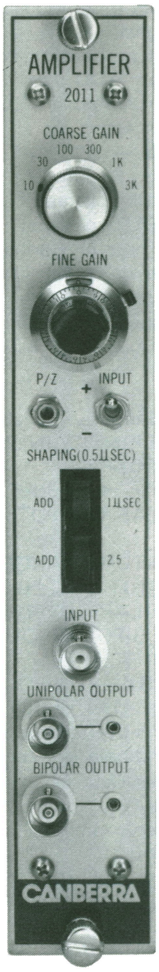
SHIPPING WEIGHT - 5.0 lbs. (2.3 kgs.)

ACCESSORIES

CABLE - one type RG-62/U (93 ohms) coaxial cable six inches in length with compatible BNC male connectors is included for external connection of Model 1718 AMPLIFIER OUTPUT/ANALYZER INPUT.



Model 2011
Spectroscopy Amplifier



Features

- Single width high performance spectroscopy amplifier
- Front panel pushbutton shaping time constants – 0.5, 1.5, 3.0 and 4.0µsec
- Ultra low noise circuitry
- Gated active baseline restorer
- Simultaneous unipolar/bipolar outputs
- Compatible with pulsed optical feedback preamplifier

Description

The Canberra Model 2011 Spectroscopy Amplifier offers a unique combination of switch selectable pulse shaping time constants and output characteristics in a single width NIM module. The Model 2011 includes the latest advance in spectroscopy amplifier technology utilizing the same state-of-the-art integrated circuits and design as Canberra's high performance spectroscopy amplifiers. The Model 2011's gain range (X3 to X3000) makes it compatible with a broad range of scintillation photomultipliers, gas proportional, silicon surface barrier and Ge(Li) detectors. The amplifier's restorer includes circuitry for sensing the reset signals present with optical coupled feedback preamplifier used with intrinsic germanium detectors.

Canberra's near-Gaussian pulse shaping is an optimum compromise between the conflicting requirements of maximizing signal-to-noise ratio and minimizing the sensitivity of output amplitude to variations in detector rise time. The active filter shaping forces a monotonic return to baseline to prevent secondary under and overshoots. The amplifier's ultra-low noise contribution and clean return to baseline results in unexcelled energy resolution. The versatility of the Model 2011 is enchanced by its choice of shaping time constants (0.5, 1.5, 3 and 4µsec) which are front panel switch selectable. Unipolar shaping is achieved with one differentiator and two active filter integrators. The differentiator is placed early in the amplifier to insure good overload recovery. The integrators are placed late to minimize noise contribution from the gain stages.

The gated active baseline restorer for the UNIPOLAR OUTPUT offers superior high count rate performance. Canberra's gated DC restoration technique virtually eliminates three undesirable characteristics inherent in most commercially available DC restorers: (1) baseline undershoots following the linear signal, (2) correlated noise, (3) non-linear response at low amplitude signals.

Simultaneous UNIPOLAR and BIPOLAR OUTPUTS are available at both front and rear panel BNC connectors. The UNIPOLAR OUTPUT is DC restored and either prompt or delayed by 2µsec.

The low spectrum broadening and excellent count rate stability achieved by this amplifier makes it an ideal instrument to insure that the superior performance of most modern detectors is realized.

The Canberra Model 2011 provides an unmatched price/performance ratio. Unexcelled energy resolution and count rate performance are provided at half the cost of some competitive units.

Specifications

INPUTS

INPUT - accepts positive or negative linear pulses from an associated preamplifier; input BNC connectors located on front and rear panels.

Amplitude - 0 to ±12 volts max, 0 to ±3.2 volts for a linear output.

Rise Time - less than SHAPING time constant selected.

Decay Time Constant - 30µsec to ∞.

Z_{in} - ≈1K ohms.

OUTPUTS

UNIPOLAR - provides positive linear pulses; BNC connectors located on front and rear panels; short circuit protected.

Amplitude - +10 volts, +12 volts maximum.

Timing - prompt or 2µsec delayed, internally selected.

Shaping - active filter near-Gaussian shaped.

Coupling - DC restored.

DC Level - factory calibrated for 0 ±5mVDC.

Front Panel Z_o - less than 1 ohm, or 93 ohms, internally selectable; rear panel is a fixed 93 ohms.

BIPOLAR - provides positive lobe leading shaped pulses, BNC connectors located on front and rear panels, short circuit protected.

Amplitude - +10 volts, +12 volts maximum.

Timing - prompt positive lobe leading.

Shaping - active filter near-Gaussian shaped.

Coupling - DC.

DC Level - less than ±20mVDC.

Front Panel Z_o - less than 1 ohm or ≈93 ohms, internally selectable.

Rear Panel Z_o - ≈93 ohms.

Specifications(continued)

FRONT PANEL CONTROLS

COARSE GAIN - six-position rotary switch selects gain factors of X10, X30, X100, X300, X1000, and X3000.

FINE GAIN - ten-turn locking dial precision potentiometer selects variable gain factor of X0.3 to X1: resetability ⩽0.03%.

P/Z - 22-turn screwdriver Pole Zero adjust to optimize amplifier baseline recovery and overload performance for the preamplifier fall time constant and the main amplifier pulse shaping chosen; 30μsec to ∞ preamp fall time constant range.

INPUT +/– - toggle switch to set Model 2011 for the polarity of the incoming preamplifier signal.

SHAPING - front panel pushbutton switches; both switches out: 0.5μsec shaping. With an ADD 1μsec pushbutton switch and an ADD 2.5μsec pushbutton switch, any combination may be selected: 0.5μsec, 1.5μsec, 3μsec or 4μsec.

INTERNAL CONTROLS

UNIPOLAR DELAY - 2 jumper plugs provided to select UNIPOLAR OUTPUT to be prompt (OUT) or delayed 2μsec. (IN). Shipped in the prompt (OUT) position.

UNIPOLAR Z OUT - jumper plug provides Z out ⩽1 ohm or Z out ≈ 93 ohms for the front panel UNIPOLAR OUTPUT signal. Shipped in the ⩽1 ohm position.

BIPOLAR Z OUT - jumper plug provides Z out ⩽1 ohm or Z out ≈93 ohms for the front panel BIPOLAR OUTPUT signal. Shipped in the ⩽1 ohm position.

PERFORMANCE

GAIN RANGE - continuously variable from X3.2 to X3000, product of COARSE and FINE GAIN controls.

GAIN DRIFT - <±0.0075%/°C.

DC LEVEL DRIFT - <±50μV/°C, typically ±10μV/°C, UNIPOLAR and BIPOLAR OUTPUTS (includes delayed restored UNIPOLAR OUTPUT).

OPERATING TEMPERATURE RANGE - 0 to 50°C.

INTEGRAL NONLINEARITY - <±0.05%, over total output range (includes restored UNIPOLAR OUTPUT).

CROSSOVER WALK - BIPOLAR OUTPUT, <±3nsec for 50:1 dynamic range.

OVERLOAD RECOVERY - UNIPOLAR (BIPOLAR) OUTPUT recovery to within ±2% (1%) of full scale output from X1000 overload in 2.5 (2.0) non-overload pulse widths, at full gain, any shaping time constant, and pole-zero cancellation properly set.

PULSE SHAPING - near-Gaussian shape; one (two for bipolar) differentiator, two active filter integrators, and only one secondary time constant (≈50msec); time to peak UNIPOLAR OUTPUT 1.75X-shaping time constant.

NOISE CONTRIBUTION - ⩽3.5μV UNIPOLAR (5.5μV BIPOLAR) OUTPUT referred to the INPUT 3μsec SHAPING and amplifier gain ⩾100 (200).

COUNT RATE PERFORMANCE

***SPECTRUM BROADENING** - FWHM of a Co^{60} 1.33MeV gamma peak for an incoming count rate of 2Kcps to 70Kcps and a 9 volt pulse height will change less than 18% for the UNIPOLAR (Prompt) OUTPUT and 1.5μsec SHAPING.

COUNT RATE STABILITY - the peak position of a Co^{60} 1.33MeV gamma peak for an incoming count rate of 2Kcps to 70Kcps and a 9 volt pulse height will shift less than 0.035% for the UNIPOLAR (Prompt) OUTPUT and 1.5μsec SHAPING.

RESTORER - active, gated (UNIPOLAR OUTPUT).

CONNECTORS

All signal connectors are BNC type.

PREAMPLIFIER POWER - rear panel, Amphenol, type 17-10090.

POWER REQUIREMENTS

+24DC — 75mA +12VDC — 35mA
-24DC — 80mA -12VDC — 45mA

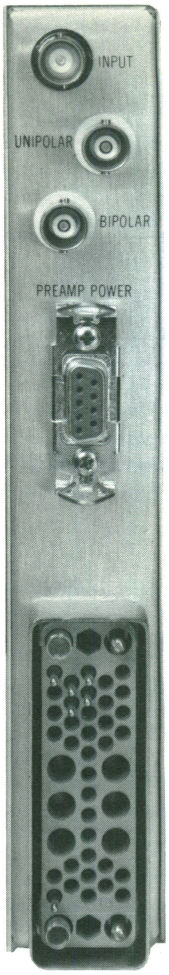
PHYSICAL

SIZE - standard single-width NIM model 1.35 x 8.71 inches (3.43 x 22.13 cm per TID 20893 (rev.)

NET WEIGHT - 2.3 lbs. (1.05 kgs).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs).

*Note: These results may not be reproducible if associated detector exhibits an inordinate amount of long rise time signals.



Model 2012 Spectroscopy Amplifier

Features

- Economical, high performance spectroscopy amplifier
- Designed for scintillation, gas proportional, and silicon surface barrier detectors
- Gated baseline restored unipolar output
- Gain of 1280
- Internal pushbutton for selection of shaping time constants of 0.5μsec or 2μsec

Description

The Model 2012 Spectroscopy Amplifier was designed using the latest integrated circuit technology to insure a long lifetime of reliable and precise operation. Key to the performance of this instrument is a simple gated baseline restorer which, because of its symmetrical characteristic, provides high resolution at an economical price.

Designed for utility, the Model 2012 offers the user spectroscopy grade performance in gain range, overload and stability for applications requiring only a fixed unipolar output.

Although it is a high performance instrument, the Model 2012 is also very versatile. It has all the characteristics necessary to make it useful with scintillation photomultipliers, gas proportional counters, and surface barrier detectors. High gain, low noise, selectable time constants, and count rate optimization are several of the more important features designed into the Model 2012.

Specifications

INPUTS

INPUT - accepts positive or negative linear pulses from associated preamplifier; amplitude 0 to ±12 volts max, 0 to ±2 volts for a linear output; rise time less than shaping time constant, decay time constant 30μsec to ∞. $Z_{in} \approx 1$K ohm; front and rear panel BNC connectors.

OUTPUTS

UNIPOLAR OUTPUT - provides positive linear pulses; BNC connectors located on front and rear panels; short circuit protected.

Amplitude - 10 volts.
Timing - prompt.
Shaping - active filter near-Gaussian shaped.
Coupling - DC restored.
DC level - factory calibrated for 0 ±5mVDC.
Front Panel Z_o - <1 ohm or ≈93 ohms, internally selectable; rear panel is ≈93 ohms.

FRONT PANEL CONTROLS

COARSE GAIN - front panel rotary switch, 32:1 range in six binary steps.

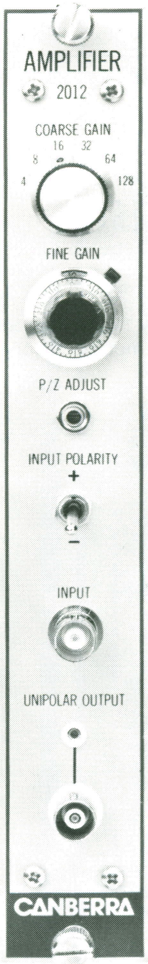
FINE GAIN - front panel, ten turn locking dial potentiometer, X3 to X10 range.

P/Z ADJUST - front panel twenty-two turn screwdriver pole zero adjustment to optimize the amplifier baseline recovery and overload performance for the preamplifier fall time constant and the main amplifier pulse shaping chosen; 30μsec to ∞ preamp fall time constant range.

INPUT POLARITY - front panel toggle switch, + (pos), - (neg) position , to set the Model 2012 for the polarity of the incoming preamplifier signal.

INTERNAL CONTROLS

SHAPING - pushbutton switch to select shaping time constants of 0.5 or 2.0μsec.



PERFORMANCE

GAIN RANGE - continuously variable from X12 to X1280, product of COARSE and FINE GAIN controls:

Coarse - X4, X8, X16, X32, X64, X128.
Fine - X3 to X10.

TEMPERATURE DRIFT:

Gain - $<\pm 0.0075\%/^{\circ}C$ of full scale.
DC Level - $<\pm 50\mu V/^{\circ}C$, typically $\pm 10\ \mu V/^{\circ}C$.

OPERATING TEMPERATURE RANGE - 0 to 50°C.

INTEGRAL NONLINEARITY - $\leqslant\pm 0.05\%$ of full scale Linear Output Range.

PULSE SHAPING - near-Gaussian shape; one differentiator, two active integral and only one secondary time constant (≈50msec); time to peak ≈1.75 X shaping time constant.

NOISE CONTRIBUTION - $<7\mu V$ RMS referred to the INPUT for gains $\geqslant 100$ and 2μsec SHAPING.

COUNT RATE PERFORMANCE

SPECTRUM BROADENING* - FWHM of a Co^{60} 1.33MeV gamma peak for an incoming count rate of 2kcps to 50kcps and a 9 volt pulse height will change less than 16% for 2µsec shaping.

PEAK STABILITY - the peak position of a Co^{60} 1.33MeV gamma peak for an incoming count rate of 2kcps to 50kcps and a 9 volt pulse height will shift less than 0.024%.

OVERLOAD RECOVERY - will recover to 2% of full scale output in 2 pulse widths for a X1000 overload with pole/zero cancellation properly set.

RESTORER - active, gated.

CONNECTORS

Signal connectors are BNC type.

PREAMPLIFIER POWER - rear panel, Amphenol #17-10090.

POWER REQUIREMENTS

+24VDC — 45mADC   +12VDC — 40mADC
- 24VDC — 50mADC   - 12VDC — 35mADC

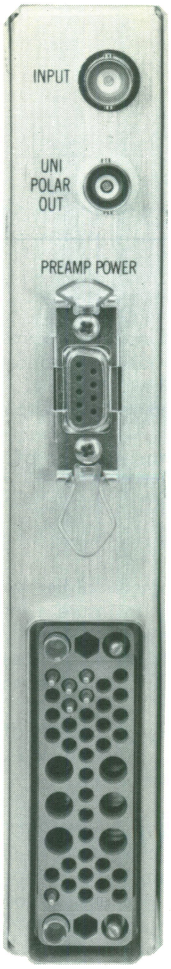
PHYSICAL

SIZE - standard single-width NIM module 1.35 x 8.71 inches (3.43 x 22.13 cm) per TID-20893 (rev)

NET WEIGHT - 2.2 lbs. (1.0 kgs).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs.).

*Note: These results may not be reproducible if associated detector exhibits an inordinate amount of long rise time signals.



Model 2015A
AMP/TSCA

Features

- Spectroscopy grade amplifier with high count rate restoration
- Timing single channel analyzer with:
  - SCA and LLD or ULD outputs
  - LLD threshold indicator for easy set-up
  - Preamp leading edge timing
- Designed for use with NaI(Tl), proportional counters, surface barrier, Ge(Li) and HPGe detectors

Description

The Canberra Model 2015A combines, in one single width module, a spectroscopy amplifier with gated base line restoration, and a timing single channel pulse height analyzer.

The spectroscopy amplifier of the Model 2015A was designed using the latest integrated circuit technology to insure a long lifetime of reliable and precise operation. Key to the high performance of this instrument is a simple gated baseline restorer which, because of its symmetrical characteristic, provides high resolution for both Ge and HPGe detectors. The reset pulses of the optical feedback preamplifier of the HPGe detector are no problem to the Model 2015A.

Although it is a high performance instrument, the Model 2015A is also very versatile. It has all the characteristics necessary to make it useful with scintillation photomultipliers, gas proportional counters, surface barrier detectors, high purity Ge and of course Ge(Li) detectors. High gain, low noise, selectable time constants, and count rate optimization are several of the more important features designed into the amplifier of the Model 2015A.

The utility of the Model 2015A derives from the dual function of its pulse height analyzer circuitry. In the SCA mode of operation a logic signal output is generated whenever the amplifier unipolar signal falls between the energy levels determined by the front panel controls (E and Δ E). This mode is especially useful when a wide dynamic range is required.

In the Timing (TSCA) mode the same logic signal is generated but it is referenced in time relative to the leading edge of the preamp signal. This provides a signal that is useful in applications requiring time coincidence.

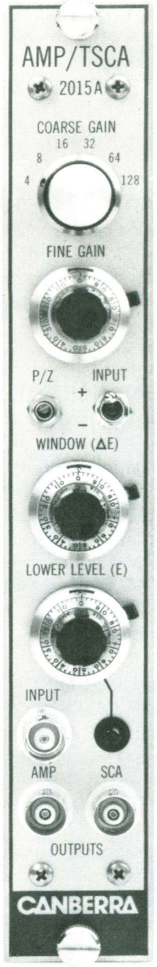
In addition to the SCA OUTPUT, the Model 2015A also provides a multifunction capability which can be programmed internally to provide a lower level (E) DISCriminator OUTPUT, or an upper level DISCriminator (E + Δ E) OUTPUT or to provide an external input level for remote control of the lower level discriminator.

Precise repeatable performance is designed and built into the 2015A. The front panel variable controls of the Model 2015A are precision ten turn potentiometers. The precision of the Δ E window setting can be further enhanced by use of a rear panel sensitivity selector switch (Δ E Range). A front panel LED indicator is provided to assist in set-up and troubleshooting. The LED is activated from the lower level discriminator and is useful for setting the discriminator just above noise.

Specifications

INPUTS

INPUT - accepts positive or negative linear pulses from associated preamplifier; amplitude 0 to ±12 volts max, 0 to ±0.84 volts for Linear output; rise time less than shaping time constant; decay time constant 30μsec to ∞; $Z_{in} \approx 1$K ohm; front and rear panel BNC connectors.



OUTPUTS

AMP OUTPUT - provides prompt +10V full scale unipolar output; active filter near-Gaussian shaping; DC restorer coupled; DC level is factory calibrated to 0 ±5mVDC; short circuit protected, front and rear panel BNC connectors; front panel $Z_o < 1$ ohms or ≈ 93 ohms, internally selectable; rear panel $Z_o \approx 93$ ohms.

SCA OUTPUT - provides a nominally 5V (unterminated) 500 nanosecond positive pulse, delayed approximately 200 nanoseconds past the peak of the AMP OUTPUT signal; rise time and fall time $\leqslant 25$ nanoseconds; $Z_o \approx 50$ ohms; BNC connectors located on front and rear panels; short circuit protected; output amplitude can be changed to 8 volts by means of an internal jumper.

INPUT/OUTPUT

DISC - rear panel BNC connector having a multi-function capability; lower level (E) DISCriminator OUTPUT, upper level (E + Δ E) DISCriminator OUTPUT or LLD SWEEP INPUT; one of these three modes is internally selected with jumper plugs; shipped in E position.

When used as:

LOWER LEVEL DISCriminator - provides a positive 5 volt (unterminated), 500 nanosecond pulse, rise time and fall time $\leqslant 25$ nanoseconds; $Z_o \approx 50$ ohms; the LLD pulse is generated when the positive edge of the AMP OUT signal crosses the LOWER LEVEL (E) threshold setting; output amplitude can be changed to +8 volts by internal jumper.

Specifications(continued)

UPPER LEVEL DISCriminator - same as lower level DISCriminator except the pulse appears when the AMP OUT signal crosses the threshold set by the sum of the LOWER LEVEL (E) and WINDOW (Δ E) controls.

LLD SWEEP INPUT - accepts 0 to +10 volts to permit external control of the analyzer lower level discriminator; Z_{in} ≈5.1 K ohms, DC coupled.

PERFORMANCE

OPERATING TEMPERATURE RANGE - 0 to 50°C.

AMPLIFIER

GAIN - continuously variable from X12 to X1280 product of COARSE and FINE GAIN controls:

- **Coarse** - X4, X8, X16, X32, X64, X128
- **Fine** - X3 to X10.

TEMPERATURE DRIFT:

- **Gain** - <±0.0075%/°C of full scale.
- **DC Level** - <±50μV/°C.

INTEGRAL NONLINEARITY - ⩽±0.05% of full scale.

PULSE SHAPING - near-Gaussian shape; one differentiator, two active integrators and only one secondary time constant (≈50msec); time to peak ≈1.75 X shaping time constant.

SHAPING TIME CONSTANTS - 0.5μsec or 2μsec unipolar shaping, internally selectable.

NOISE CONTRIBITION - <7μV referred to the INPUT for gains ⩾100X and 2μsec SHAPING.

COUNT RATE PERFORMANCE:

Spectrum Broadening* - FWHM of a Co^{60} 1.33MeV gamma peak for an incoming count rate of 2kcps to 50kcps and a 9 volt pulse height will change less than ±16%.

Peak Stability - the peak position of a Co^{60} 1.33MeV gamma peak for an incoming count rate of 2kcps to 50kcps and a 9 volt pulse height will shift less than ±0.024%.

OVERLOAD RECOVERY - will recover to ±2% of full scale output in 2 pulse widths for a X1000 overload with pole/zero cancellation properly set.

RESTORER - active, gated.

SCA

By means of an internal jumper, the SCA OUTPUT can be used as an SCA, referenced to the AMP OUTPUT crossing the LOWER LEVEL (E) discriminator; or, a Timing SCA, referenced to the leading edge of the amplified preamp signal. Unit is shipped with the jumper in the Timing SCA mode.

TSCA OUTPUT TIMING - ≈200 nanoseconds from the peak of the AMP OUT signal.

Walk - ⩽±50 nanoseconds for a 50:1 change in the AMP OUTPUT signal amplitude.

INTEGRAL NONLINEARITY - ⩽±0.25% of full scale range for LOWER LEVEL (E) and WINDOW (Δ E).

PULSE PAIR RESOLUTION - SCA driven from a rectangular shaped pulser, for LOWER LEVEL (E) threshold ⩾100mV the pulse pair resolution is ⩽500 nanoseconds over the full linear range, for the DISC (LLD) output.

TEMPERATURE DRIFT:

- **Lower Level (E)** - ⩽±0.005% of full scale/°C (50PPM).
- **Window (Δ E)** - ⩽±0.005% of full scale/°C (50PPM).

POWER SUPPLY SENSITIVITY - both discriminators are referenced to the +12 and +24V Bin supplies.

CONTROLS

COARSE GAIN - front panel rotary switch, 32:1 range in six binary steps.

FINE GAIN - front panel, ten-turn locking dial potentiometer, X3 to X10 range, allowing maximum accuracy and resetability.

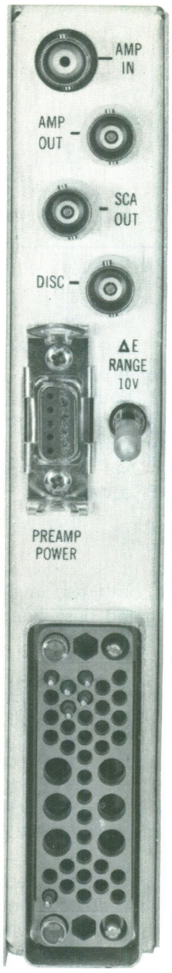
P/Z - front panel twenty-two turn screwdriver pole zero adjustment to optimize the amplifier baseline recovery and overload performance for the preamplifier fall time constant and the main amplifier pulse shaping chosen; 30μsec to ∞ preamp fall time constant range.

INPUT +/— - front panel toggle switch. + (pos). — (neg) positions, to set the Model 2015A for the polarity of the incoming preamplifier signal.

TIME CONSTANTS - internal pushbutton switch to select SHAPING TIME constant of 0.5 or 2.0 microseconds.

LOWER LEVEL (E) - front panel ten-turn locking dial precision potentiometer to select a baseline from 0.1 volts to 10 volts for the timing SCA mode, and 0 ±15mV to 10 volts for the normal SCA mode.

*Note: - These results may not be reproducible if associated detector exhibits an inordinate amount of long rise time signals.



LED INDICATOR - a LED lamp is provided to air the user when setting the LLD just above the system noise.

WINDOW (Δ E) - front panel ten-turn locking dial precision potentiometer to select window width from 0 to 10 volts or 0 to 1 volts depending on the rear panel Δ RANGE switch.

Δ E RANGE - rear panel two-position toggle switch which changes the front panel WINDOW (Δ E) range of 0 to 10 volts or 0 to 1 volt full scale.

INTERNAL CONTROLS

Z_{out} - 2 position jumper plug that selects AMP OUTPUT impedance of ⩽1 ohm or ≈93 ohms.

DISC A - 2-position jumper plug that sets the rear panel DISC BNC CONNECTOR as an output or input.

DISC B - 2-position jumper plug that sets the rear panel DISC BNC CONNECTOR to output the LOWER LEVEL (E) discriminator or the UPPER LEVEL (Δ E) discriminator when DISC A is in the OUT position.

LLD - 2-position jumper plug that sets the LOWER LEVEL discriminator threshold as INTernal or EXTernal; if EXTernal, the DISC A jumper plug must be in the IN position to allow the rear panel DISC BNC CONNECTOR to be used as the LLD SWEEP input.

SCA MODE - 2-position jumper plug which allows the SCA to operate in the TSCA or SCA mode.

CONNECTORS

All signal connectors are BNC type.

PREAMPLIFIER POWER - rear panel, Amphenol #17-10090.

POWER REQUIREMENTS

+24VDC	—	50mA	+12VDC	—	160mA
- 24VDC	—	50mA	- 12VDC	—	70mA

PHYSICAL

SIZE - standard single-width NIM module 1.35 x 8.71 inches (3.43 x 22.13 cm) per TID 20893 (rev.).

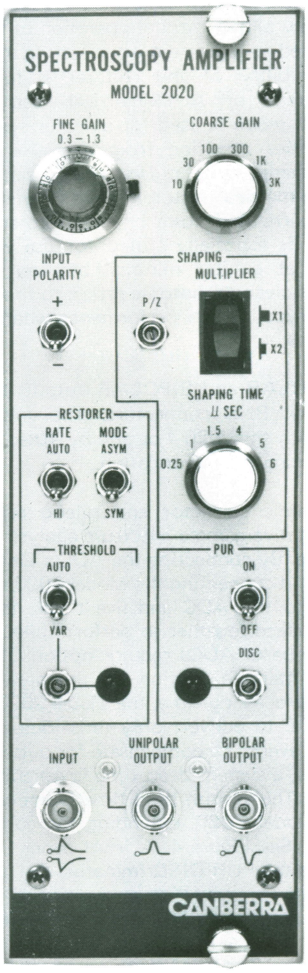
NET WEIGHT - 2.5 lbs. (1.1 kgs.).

SHIPPING WEIGHT - 5.0 lbs. (2.3 kgs.).

Model 2020
Spectroscopy Amplifier

Features

- 12 front panel selectable shaping time constants
- Noise $\leqslant 3.4\mu V$ RMS referred to input at gain $\geqslant 100$ and $3\mu sec$ shaping
- DC drift $\leqslant \pm 10\mu V/^{o}C$
- Unique active baseline restorer with:
  1. Automatic or fixed restorer rates
  2. Automatic or manual threshold adjustment
  3. Selectable symmetry for excellent high count rate performance
- Accommodates pulsed optical feedback preamplifiers
- Leading and trailing edge pulse pileup rejection
- Live time correction for pulse pileup and amplifier dead time


SPECTROSCOPY AMPLIFIER
MODEL 2020
FINE GAIN
0.3 – 1.3
COARSE GAIN
10
30
100
300
1K
3K
INPUT
POLARITY
+
–
SHAPING
P/Z
MULTIPLIER
X1
X2
SHAPING TIME
µ SEC
0.25
1
1.5
4
5
6
RESTORER
RATE
AUTO
HI
MODE
ASYM
SYM
THRESHOLD
AUTO
VAR
PUR
ON
OFF
DISC
INPUT
UNIPOLAR
OUTPUT
BIPOLAR
OUTPUT
CANBERRA

Description

The Canberra Model 2020 Spectroscopy Amplifier offers the modern spectroscopist more performance, features and flexibility than any other nuclear pulse amplifier available today. Functionally, the Model 2020 provides in a double width NIM module an exceptional spectroscopy amplifier, a gated active baseline restorer, a pulse pileup rejector and a live time corrector.

Canberra's near-Gaussian filter shaping, well known and now emulated by others in the industry, has been refined in the Model 2020 for improved pulse symmetry, minimum sensitivity of output amplitude to variations in detector rise time, and maximum signal to noise ratio. For a given shaping time constant, the improved pulse symmetry minimizes the pulse dwell time by tucking in the trailing skirt of the unipolar pulse shape. This allows a faster return to the baseline. The result is superior energy resolution, count rate and throughput performance. Figure 1 illustrates typical noise verses shaping time constant and Figure 2 demonstrates typical resolution and peak shift performance verses count rate. Unipolar shaping is achieved with one differentiator and two active filter integrators. The differentiator is placed early in the amplifier to insure good overload recovery. The integrators are placed late to minimize noise contribution from the gain stages. The amplifier offers 12 front panel switch selectable pulse SHAPING time constants of 0.25, 0.5, 1, 1.5, 2, 3, 4, 5, 6, 8, 10 and 12µsec.

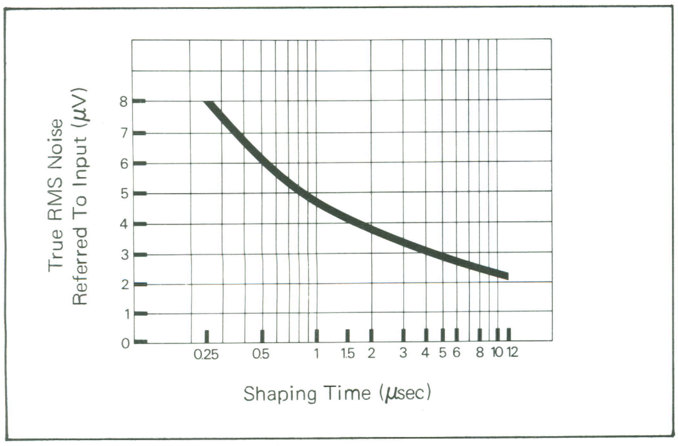


Figure 1.
Typical Model 2020 Unipolar Output True RMS Noise (referred to input for gain of 100) vs. Shaping Time constant.

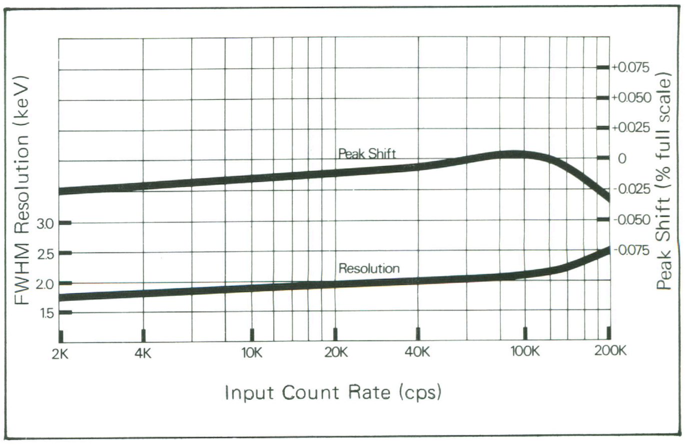


Figure 2.
Typical Model 2020 Resolution and Peak Shift Stability vs. Counting Rate for 2µsec shaping, AUTO Restorer Rate, AUTO Restorer Threshold, ASYM Restorer Mode and a 1.33 Mev Co-60 Gamma Peak.

Description (continued)

The Canberra gated DC restorer offers automatic features on both the restorer threshold and restorer rate assuring the best possible low and high count rate performance. Amplifier performance is very much dependent on the restorer rate and threshold settings. The Model 2020 includes circuitry which automatically and continuously samples the amplifier output noise and count rate, and automatically sets the respective restorer threshold and rate with precision for optimum performance. The restorer is also flexible. The discriminating researcher can overide the automatic restorer features. Setting the RESTORER RATE and THRESHOLD switches to their manual positions HIgh and VARiable respectively allows manual operation of the restorer. A front panel LED is provided as a user aid when setting the restorer threshold manually. The flexibility of the restorer is further enhanced by providing SYMmetrical or ASYMmetrical restorer selection. The symmetrical restorer mode is used for detector systems which exhibit baseline discontinuities resulting from excessive noise and/or high voltage effects, preamp reset pulses and preamp secondary time constants. The asymmetrical restorer mode virtually eliminates charge accumulation and correlated noise on the restorer holding capacitor. This restorer mode is especially suited for use with high resolution detector systems that exhibit minimal baseline discontinuities and whose signals have a clean monotonic return to the baseline. The result is superior resolution/count rate performance when compared to more conventional methods.

Simultaneous UNIPOLAR and BIPOLAR outputs are available at both front and rear panel BNC connectors. The unipolar signal can be delayed 2µsec, or with the 2020-4 option by 4µsec. The bipolar output can be used for counting, timing or gating.

The internal live time corrector and pileup rejector provides the capability of quantitative gamma spectrum analysis nearly independent of system count rate. By connecting the ADC's Linear Gate ($\overline{\text{LG}}$) signal to the Model 2020 and connecting the Model 2020's REJECT and Dead Time ($\overline{\text{DT}}$) signals to the ADC and live timer, the Model 2020 and associated ADC interface together to perform pileup rejection and live time correction. Canberra ADCs require option 01 to operate in this manner (see ADC Interface Section on the next page). During the amplifier and ADC processing time, the Model 2020 inspects for pileup and permits the ADC to convert only those detector signals resulting from a single energy event. To compensate for pulses rejected, amplifier and ADC dead times, a system dead time is generated by the live time correction function. The system dead time is the composite dead time of the ADC and Model 2020, extending the collection time by the appropriate amount. See Figure 4. A front panel LED is provided as a user aid when setting the PUR DISCriminator.

The Model 2020's exceptional DC stability and ultra low noise ensure that optimum performance is realized. Together with its broad gain range (X3 to X3900), 12 shaping time constants, pileup rejection and live time correction the Model 2020 offers uncompromising performance when used with Germanium, Silicon, Scintillation, Gas Proportional and Surface Barrier detectors.

Specifications

INPUTS

INPUT - accepts positive or negative pulses from an associated preamplifier; amplitude: ± 10 volts ÷ selected gain, ± 12 volts maximum; rise time: less than SHAPING time constant; decay time constant: 40 µsec to ∞for 0.25, 0.5, 1, 1.5, 2, 3, and 4 µsec shaping time constants, 100 µsec to ∞for 5, 6, 8, 10 and 12 µsec shaping time constants; input impedance: ≈ 1 k ohms; input BNC connectors located on front and rear panel.

$\overline{\text{LG}}$ - receives a negative logic pulse from the ADC. Used to indicate to the Model 2020 that the ADC has accepted and is processing an event; input is TTL compatible, logic low when ADC accepts input, returning to a logic high at the conclusion of the ADC acquisition cycle; loading: 4.7 k ohm pull up resistor; input pulse rise time to be <350 nsec. Accessible through rear panel PUR Connector.

PUR INHIBIT - receives a logic pulse from associated pulsed optical feedback preamplifier used to extend the Model 2020 $\overline{\text{DT}}$ signal, inhibit and reset the pileup rejector during the preamplifier's reset cycle; internal jumper provides the option of either INB (positive true) or $\overline{\text{INB}}$ (negative true) logic pulses; INB V_{HI} (true): 2 to 5 volts; V_{LO}: 0 to 1.5 volts; I_{HI}: 3.2 mA at 3 volts; $\overline{\text{INB}}$ V_{LO} (true): 0 to 1 volt, V_{HI}: 2.5 to 5 volts, I_{LO}: -3.6 mA at 0 volts; BNC connector located on rear panel.

OUTPUTS

UNIPOLAR OUTPUT - provides positive linear active filter near-Gaussian shaped pulses; amplitude linear to + 10 volts, 12 volts max.; D.C. restored; output D.C. level factory calibrated to 0 ± 5mV, front panel output impedance less than 1 ohm or ≈93 ohms internally selectable; rear panel output impedance ≈93 ohms; short circuit protected; prompt or delayed 2µsec (4µsec with 2020-4 option); BNC connectors located on front and rear panels.

BIPOLAR OUTPUT - provides prompt positive lobe leading linear active filter bipolar shaped pulses; amplitude linear to + 10 volts, 12 volts max., negative lobe is approximately 70% of positive lobe; D.C. coupled; output D.C. level ± 25mV; front panel output impedance less than 1 ohm or ≈93 ohms, internally selectable; rear panel output impedance ≈ 93 ohms; short circuit protected; BNC connectors located on front and rear panels.

$\overline{\text{DT}}$ - provides a negative logic signal and when "OR"ed together with the ADC dead time, at the ADC's live timer, provides live time correction for the amplifier and pileup rejector. Output is TTL compatible, open collector with 1k pull up resistor through 47 ohm output resistor. Logic low when system is busy, logic high otherwise. BNC connector located on rear panel.

REJECT - provides a logic signal used to initiate an ADC reject sequence for corresponding piled up input events that occur during the ADC's Linear Gate ($\overline{\text{LG}}$) time; internal jumper provides the option of either REJ (positive true) or $\overline{\text{REJ}}$ (negative true) logic pulse. TTL compatible, totem pole output through 47 ohm resistor. Accessible through rear panel PUR Connector.

FRONT PANEL CONTROLS

COARSE GAIN - 6 position rotary switch selects gain factors of X10, X30, X100, X300, X1000 and X3000.

FINE GAIN - ten-turn locking dial precision potentiometer selects variable gain factor of X0.3 to X1.3 resetability ≤0.03%.

INPUT POLARITY - 2 position toggle switch to set the Model 2020 for the polarity of the incoming preamplifier signal.

P/Z - 22-turn screwdriver pole zero potentiometer to optimize amplifier baseline recovery and overload performance for the preamplifier fall time constant and the Model 2020's pulse shaping chosen; 40 µsec to ∞for 0.25, 0.5, 1, 1.5, 2, 3 and 4 µsec SHAPING time constants, 100 µsec to ∞for 5, 6, 8, 10 and 12 µsec SHAPING time constants.

SHAPING TIME - 6 position rotary switch; provides 0.25, 1, 1.5, 4, 5 and 6µsec basic shaping time constants.

MULTIPLIER - multiplies SHAPING TIME setting by X1 or X2 giving additional shaping time constants of 0.5, 2, 3, 8, 10 and 12µsec, a total of 12 shaping time constants.

RESTORER RATE - 2 position toggle switch to set the baseline restorer rate (slew rate); AUTO: the baseline restorer rate is automatically optimized by internal circuitry as a function of unipolar output signal duty cycle and count rate; High: when selected sets the baseline restorer to a fixed high rate.

RESTORER MODE - 2 position toggle switch to select SYMmetrical or ASYMmetrical baseline restorer modes.

THRESHOLD AUTO/VAR - 2 position toggle switch to set the baseline restorer threshold; AUTO:the baseline restorer threshold is automatically optimized by internal circuitry as a function of the unipolar output signal noise level; VARiable: provides a manual variable baseline threshold adjustment range of 0 volts to 200mVDC. The negative (referenced to the UNIPOLAR OUTPUT) threshold is set at -500mVDC. An LED indicator is provided as a user-aid for set up convenience.

PUR ON/OFF - 2 position toggle switch to enable (ON) or disable (OFF) the pileup rejector and live time corrector.

PUR DISC - 22 turn screwdriver adjustment potentiometer for optimizing the pileup rejector discriminator threshold level. Provides a variable range of 0 to 550mV. An LED indicator is provided to aid the user when setting the PUR DISC just above the system noise.

INTERNAL CONTROLS

UNIPOLAR DELAY - 2 jumper plugs provided to select UNIPOLAR output to prompt (OUT) or delayed 2µsec (IN), or 4µsec on option 2020-4. Shipped in the prompt (OUT) position.

UNIPOLAR Z_{out} - jumper plug provides $Z_{out} \leqslant 1$ ohm or ≈ 93 ohms for the front panel UNIPOLAR output. Shipped in the $\leqslant 1$ ohm position.

BIPOLAR Z_{out} - jumper plug provides $Z_{out} \leqslant 1$ ohm or ≈ 93 ohms for the front panel BIPOLAR output. Shipped in the $\leqslant 1$ ohm position.

INB/$\overline{\text{INB}}$ - jumper plug J5 allows the PUR INHIBIT input to accept either positive true or negative true logic signals. Shipped in the INB (positive true) position.

REJ/$\overline{\text{REJ}}$ - jumper plug J6 allows the reject output to be a positive true or negative true logic signal. Shipped in the REJ (positive true) position.

L/E - jumper plug J7 selects a linear or exponential restorer response. Shipped in the L (linear) position.

PERFORMANCE

AMPLIFIER

GAIN RANGE - continuously variable from X3 to X3900, product of COARSE and FINE GAIN controls.

OPERATING TEMPERATURE RANGE - 0 to 50°C.

GAIN DRIFT - $\leqslant \pm 0.0075\%/^{\circ}C$.

DC LEVEL DRIFT - UNIPOLAR output: $\leqslant \pm 10 \mu V/^{\circ}C$; BIPOLAR output: $\leqslant \pm 50 \mu V/^{\circ}C$.

INTEGRAL NON-LINEARITY - $\leqslant \pm 0.05\%$, over total output range for 2µsec shaping.

CROSSOVER WALK - BIPOLAR output: $\leqslant \pm$ 3nsec for 50:1 dynamic range and 2µsec shaping when used with Canberra Model 2037A Edge/Crossover Timing Single Channel Analyzer.

OVERLOAD RECOVERY - UNIPOLAR (BIPOLAR) output recovery to within ± 2% (1%) of full scale output from X1000 overload in 2.5 (2.0) non-overloaded pulse widths, at full gain, any shaping time constant and pole-zero cancellation properly set.

NOISE CONTRIBUTION - $\leqslant 3.2 \mu V$ true RMS UNIPOLAR ($7.1 \mu V$ BIPOLAR) output referred to input, 3µsec shaping and amplifier gain $\geqslant 100$.

PULSE SHAPING - near-Gaussian shape: one differentiator (two for bipolar), two active filter integrators; UNIPOLAR time to peak: 2.35X shaping time; pulse width: 7.3X shaping time; BIPOLAR time to crossover: 2.8X shaping time, time to peak, pulse width and crossover times measured at 0.1% of full scale output; 1 µsec SHAPING center frequency: 150 kHz; band width: 180 kHz; f_c and BW for other shaping are multiples of that given for 1 µsec.

RESTORER - active gated.

* **SPECTRUM BROADENING** - the FWHM of a Co-60 1.33 MeV gamma peak for an incoming rate of 2kcps to 100kcps and a 9 volt pulse height will typically change less than 14% for 2µsec shaping, AUTO Restorer Rate, AUTO Restorer Threshold and ASYM Restorer Mode.

COUNT RATE STABILITY - the peak position of a Co-60 1.33 MeV gamma peak for an incoming count rate of 2kcps to 100kcps and a 9 volt pulse height will typically shift less than 0.024% for 2µsec shaping, AUTO Restorer Rate, AUTO Restorer Threshold and ASYM Restorer Mode.

* Note: These results may not be reproducible if associated detector exhibits an inordinate amount of long rise time signals.

PILEUP REJECTOR/LIVE TIME CORRECTOR

PULSE PAIR RESOLUTION - $\leqslant$500nsec.

MINIMUM DETECTABLE SIGNAL - Limited by detector/preamp noise characteristics.

ADC INTERFACE - Compatible Canberra ADC's (with factory installed options) are available and can be ordered using the following designations:

Model 8070 with Option 01
Model 8070A with Option 01
Model 8080 with Option 01
Model 8100 (MCA) with Option 31

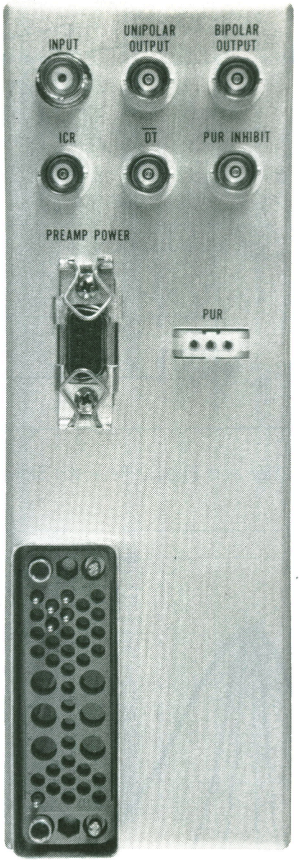
For use with existing systems, detailed instructions are provided in the 2020 manual to allow the user to adapt his ADC to interface with the Model 2020 for pileup rejection and live time correction.

POWER REQUIREMENTS

+24VDC — 110mA   +12VDC — 180mA
- 24VDC — 150mA   - 12VDC — 75mA

CONNECTORS

With the exception of the PUR and PREAMP POWER connectors, all signal connectors are BNC type.



PUR - Molex receptable #03-06-2032 mating cable plug supplied as an accessory.

PREAMP POWER - rear panel, Amphenol, type 17-10070.

ACCESSORIES - Molex cable plug #03-06-2032 and 3 associated male pins #02-06-2132.

PHYSICAL

SIZE - standard double-width NIM module 2.70 x 8.71 inches (6.85 x 22.13 cm) per TID-20893 (rev.).

NET WEIGHT - 2.9 lbs. (1.3 kgs).

SHIPPING WEIGHT - 5.0 lbs. (2.3 kgs).

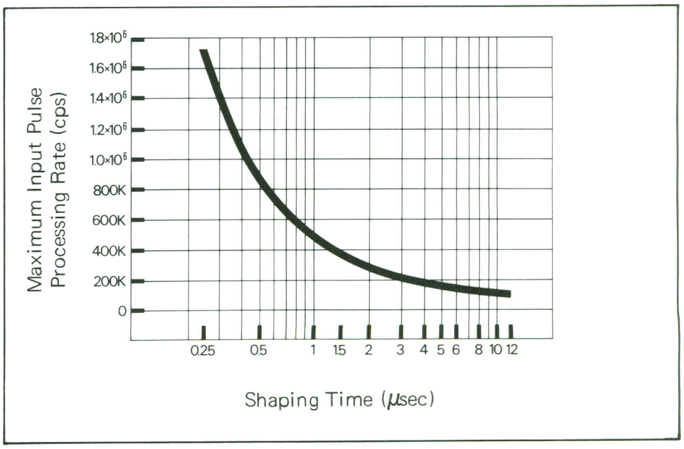


Figure 3.
Typical Model 2020 Maximum Input Pulse Processing Rate verses shaping time constant.

* Maximum Input Pulse Processing Rate: Maximum amplifier input count rate (pulses per second) for which the amplifier's DC restorer maintains the baseline at reference ground.

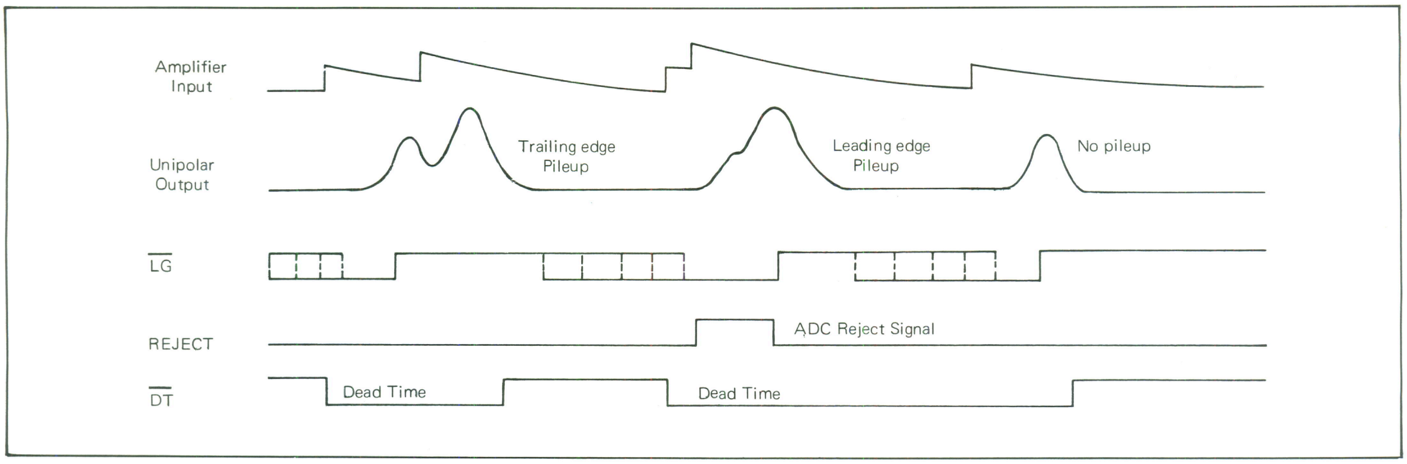

Amplifier Input
Unipolar Output
Trailing edge Pileup
Leading edge Pileup
No pileup
LG
REJECT
ADC Reject Signal
DT
Dead Time
Dead Time

Figure 4.
Relationship of Amplifier and Pileup Rejector Signals.

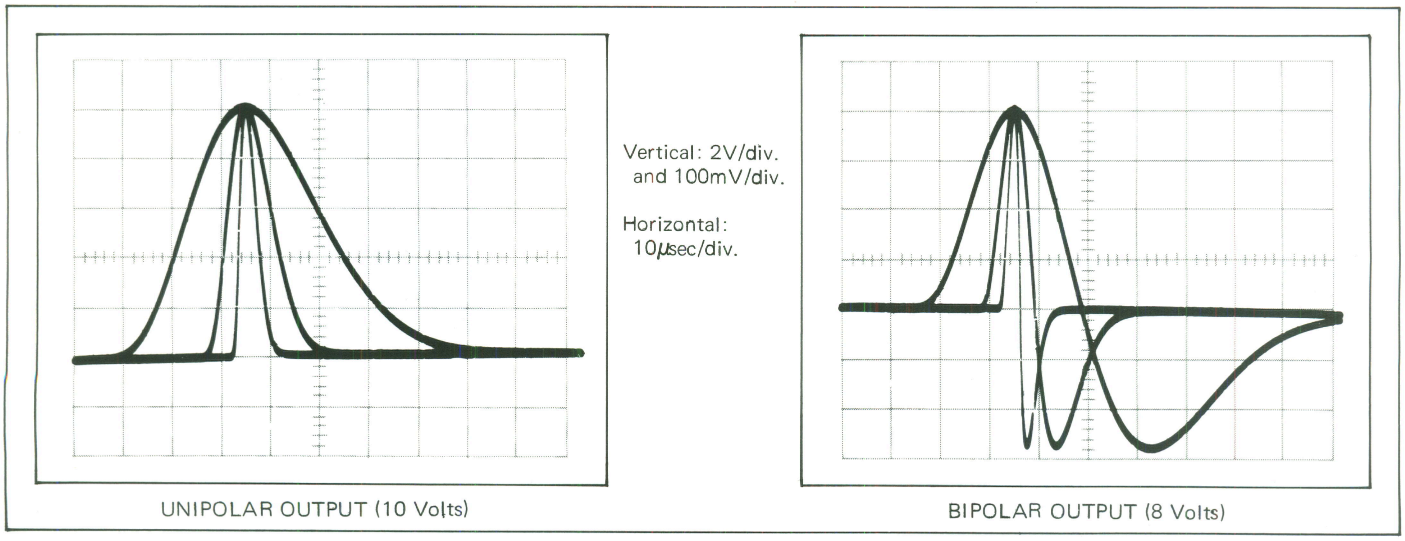


Figure 5.
Model 2020 SHAPING selected for 12, 4 and 1.5 μsec.

During the amplifier and ADC processing time, the Model 2020 inspects for pileup and permits the ADC to convert only those detector signals resulting from a single energy event, see Figure 6.

Note the reduction in amplitude of both sum peaks and background. Also note the improved resolution of the sum peaks. The background reduction and improved resolution are directly indicative of the Pileup Rejector's capabilities, since only sum peak pulses which are indeed 100% in coincidence should be processed.

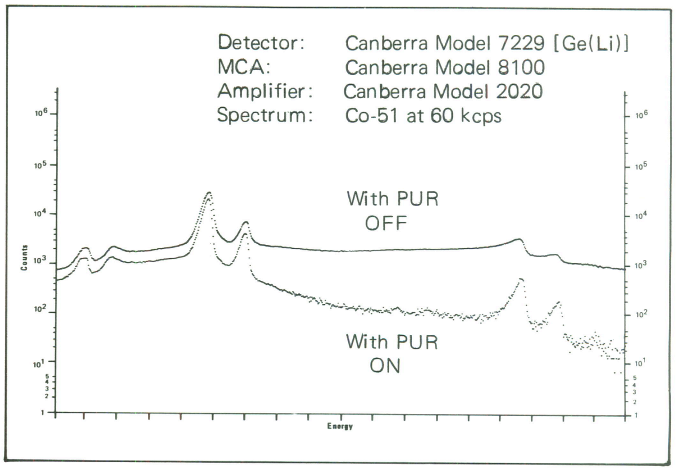
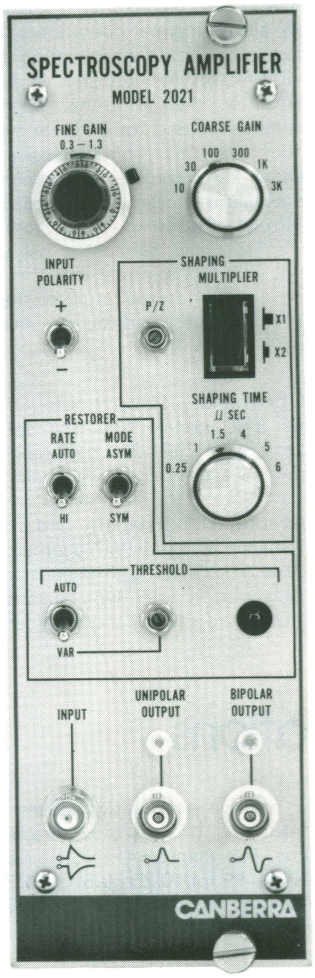


Figure 6.
Co-57 spectrum at 80 kcps and 4 μsec shaping.

Model 2021
Spectroscopy Amplifier

Features

- 12 front panel selectable shaping time constants
- Noise ⩽3.4 μV RMS referred to input at gain ⩾100 and 3 μsec shaping
- DC drift ⩽±10 μV/°C
- Unique active baseline restorer with:
  1. Automatic or fixed restorer rates
  2. Automatic or manual threshold adjustment
  3. Selectable symmetry for excellent high count rate performance


SPECTROSCOPY AMPLIFIER
MODEL 2021
FINE GAIN
0.3 – 1.3
COARSE GAIN
10
30
100
300
1K
3K
INPUT POLARITY
+
−
SHAPING MULTIPLIER
P/Z
X1
X2
SHAPING TIME
μ SEC
0.25
1
1.5
4
5
6
RESTORER
RATE
AUTO
HI
MODE
ASYM
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INPUT
UNIPOLAR OUTPUT
BIPOLAR OUTPUT
CANBERRA

Description

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Canberra's near-Gaussian filter shaping, well known and now emulated by others in the industry, has been refined in the Model 2021 for improved pulse symmetry, minimum sensitivity of output amplitude to variations in detector rise time, and maximum signal to noise ratio. For a given shaping time constant, the improved pulse symmetry minimizes the pulse dwell time by tucking in the trailing skirt of the unipolar pulse shape. This allows a faster return to the baseline. The result is superior energy resolution, count rate and throughput performance. Figure 1 illustrates typical noise verses shaping time constant and Figure 2 demonstrates typical resolution and peak shift performance verses count rate. Unipolar shaping is achieved with one differentiator and two active filter integrators. The differentiator is placed early in the amplifier to insure good overload recovery. The integrators are placed late to minimize noise contribution from the gain stages. The amplifier offers 12 front panel switch selectable pulse SHAPING time constants of 0.25, 0.5, 1, 1.5, 2, 3, 4, 5, 6, 8, 10 and 12 μsec.

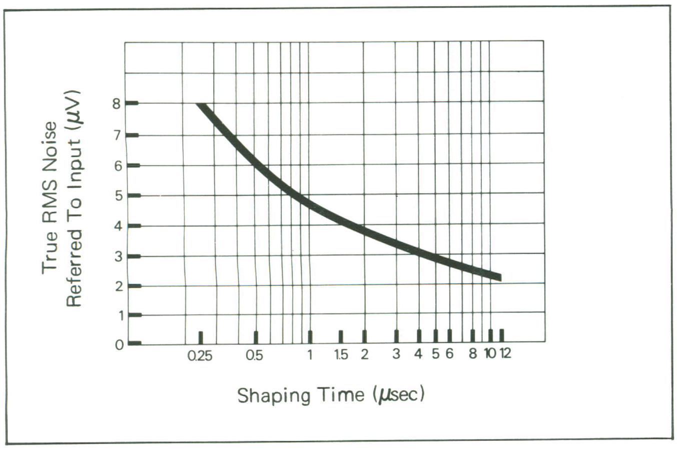


Figure 1.
Typical Model 2021 Unipolar Output True RMS Noise (referred to input for gain of 100) vs. Shaping Time constant.

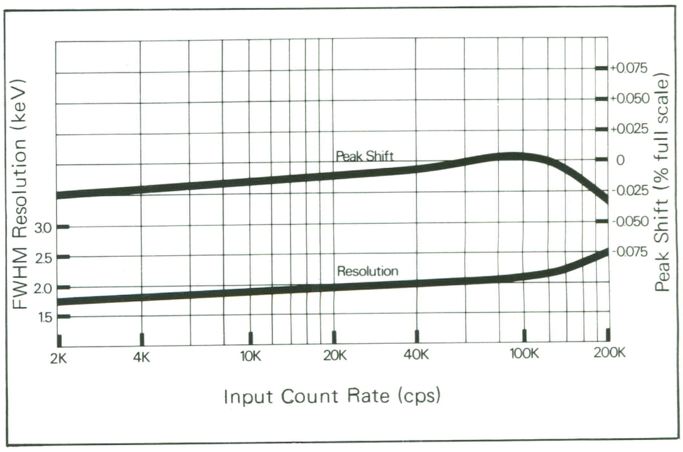


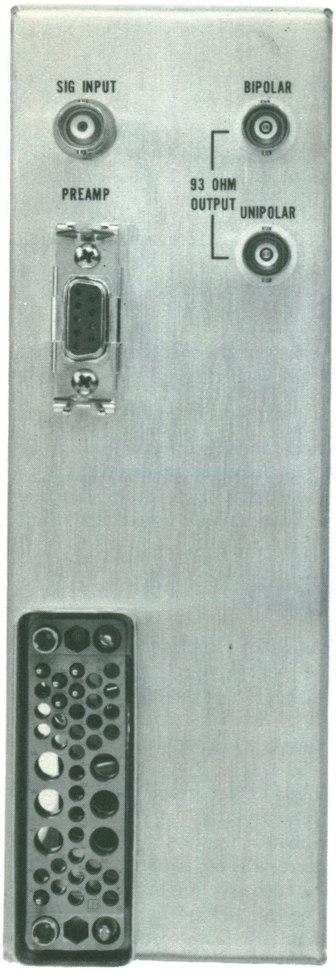
Figure 2.
Typical Model 2021 Resolution and Peak Shift Stability vs. Counting Rate for 2 μsec shaping, AUTO Restorer Rate, AUTO Restorer Threshold, ASYM Restorer Mode and a 1.33 MeV Co-60 Gamma Peak.

Description (continued)

The Canberra gated DC restorer offers automatic features on both the restorer threshold and restorer rate assuring the best possible low and high count rate performance. Amplifier performance is very much dependent on the restorer rate and threshold settings. The Model 2021 includes circuitry which automatically and continuously samples the amplifier output noise and count rate, and automatically sets the respective restorer threshold and rate with precision for optimum performance. The restorer is also flexible. The discriminating researcher can override the automatic restorer features. Setting the RESTORER RATE and THRESHOLD switches to their manual positions HIgh and VARiable respectively allows manual operation of the restorer. A front panel LED is provided as a user aid when setting the restorer threshold manually. The flexibility of the restorer is further enhanced by providing SYMmetrical or ASYMmetrical restorer selection. The symmetrical restorer mode is used for detector systems which exhibit baseline discontinuities resulting from excessive noise and/or high voltage effects, preamp reset pulses and preamp secondary time constants. The symmetrical restorer mode virtually eliminates charge accumulation and correlated noise on the restorer holding capacitor. This restorer mode is especially suited for use with high resolution detector systems that exhibit minimal baseline discontinuities and whose signals have a clean monotonic return to the baseline. The result is superior resolution/count rate performance when compared to more conventional methods.

Simultaneous UNIPOLAR and BIPOLAR outputs are available at both front and rear panel BNC connectors. The unipolar signal can be delayed by 2 µsec with option 2021-2 or by 4 µsec with option 2021-4. The bipolar output can be used for counting, timing or gating.

The Model 2021's exceptional DC stability and ultra low noise ensure that optimum performance is realized. Together with its broad gain range (X3 to X3900) and 12 shaping time constants, the Model 2021 offers uncompromising performance when used with Germanium, Silicon, Scintillation, Gas Proportional and Surface Barrier detectors.



Specifications

INPUTS

INPUT - accepts positive or negative pulses from an associated preamplifier; amplitude: ±10 volts ÷ selected gain, ±12 volts maximum; rise time: less than SHAPING time constant; decay time constant: 40 µsec to ∞ for 0.25, 0.5, 1, 1.5, 2, 3, and 4 µsec shaping time constants, 100 µsec to ∞ for 5, 6, 8, 10 and 12 µsec shaping time constants; input impedance: ≈1k ohms; input BNC connectors located on front and real panel.

OUTPUTS

UNIPOLAR OUTPUT - provides positive linear active filter near-Gaussian shaped pulses; amplitude linear to + 10 volts, 12 volts max.; D.C. restored; output D.C. level factory calibrated to 0 ± 5 mV, front panel output impedance less than 1 ohm or ≈93 ohms internally selectable; rear panel output impedance ≈93 ohms; short circuit protected; prompt or delayed 2 µsec with option 2021-2 or 4 µsec with option 2021-4; BNC connectors located on front and rear panels.

BIPOLAR OUTPUT - provides prompt positive lobe leading linear active filter bipolar shaped pulses; amplitude linear to + 10 volts, 12 volts max., negative lobe is approximately 70% of positive lobe; D.C. coupled; output D.C. level ±25 mV; front panel output impedance less than 1 ohm or ≈93 ohms, internally selectable; rear panel output impedance ≈93 ohms; short circuit protected; BNC connectors located on front and rear panels.

FRONT PANEL CONTROLS

COARSE GAIN - 6 position rotary switch selects gain factors of X10, X30, X100, X300, X1000 and X3000.

FINE GAIN - ten-turn locking dial precision potentiometer selects variable gain factor of X0.3 to X1.3 resetability ≤0.03%.

INPUT POLARITY - 2 position toggle switch to set the Model 2021 for the polarity of the incoming preamplifier signal.

P/Z - 22-turn screwdriver pole zero potentiometer to optimize amplifier baseline recovery and overload performance for the preamplifier fall time constant and the Model 2021's pulse shaping chosen; 40 µsec to ∞ for 0.25, 0.5, 1, 1.5, 2, 3 and 4 µsec SHAPING time constants, 100 µsec to ∞ for 5, 6, 8, 10 and 12 µsec SHAPING time constants.

SHAPING TIME - 6 position rotary switch; provides 0.25, 1, 1.5, 4, 5 and 6 µsec basic shaping time constants.

MULTIPLIER - multiplies SHAPING TIME setting by X1 or X2 giving additional shaping time constants of 0.5, 2, 3, 8, 10 and 12 µsec, a total of 12 shaping time constants.

RESTORER RATE - 2 position toggle switch to set the baseline restorer rate (slew rate); AUTO: the baseline restorer rate is automatically optimized by internal circuitry as a function of unipolar output signal duty cycle and count rate; HIgh: when selected sets the baseline restorer to a fixed high rate.

RESTORER MODE - 2 position toggle switch to select SYMmetrical or ASYMmetrical baseline restorer modes.

THRESHOLD AUTO/VAR - 2 position toggle switch to set the baseline restorer threshold; AUTO: the baseline restorer threshold is automatically optimized by internal circuitry as a function of the unipolar output signal noise level; VARiable: provides a manual variable baseline threshold adjustment range of 0 volts to 200 mV dc. The negative (referenced to the UNIPOLAR OUTPUT) threshold is set at -500 mV dc. An LED indicator is provided as a user-aid for set up convenience.

INTERNAL CONTROLS

UNIPOLAR DELAY - 2 jumper plugs provided to select UNIPOLAR output for prompt (OUT) or optional delay (IN). Delay selected for either 2 µsec with option 2021-2 or 4 µsec with option 2021-4. Shipped in the prompt (OUT) position.

UNIPOLAR Z_{out} - jumper plug provides Z_{out} ≤1 ohm or ≈93 ohms for the front panel UNIPOLAR output. Shipped in the ≤1 ohm position.

BIPOLAR Z_{out} - jumper plug provides $Z_{out} \leqslant 1$ ohm or ≈ 93 ohms for the front panel BIPOLAR output. Shipped in the $\leqslant 1$ ohm position.
L/E - jumper plug J7 selects a linear or exponential restorer response. Shipped in the L (linear) position.

PERFORMANCE

GAIN RANGE - continuously variable from X3 to X3900, product of COARSE and FINE GAIN controls.
OPERATING TEMPERATURE RANGE - 0 to 50°C.
GAIN DRIFT - $\leqslant \pm 0.0075\%/^{\circ}C$.
DC LEVEL DRIFT - UNIPOLAR output: $\leqslant \pm 10\ \mu V/^{\circ}C$; BIPOLAR output: $\leqslant \pm 50\ \mu V/^{\circ}C$.
INTEGRAL NON-LINEARITY - $\leqslant \pm 0.05\%$, over total output range for 2 μsec shaping.
CROSSOVER WALK - BIPOLAR output: $\leqslant \pm 3$ nsec for 50:1 dynamic range and 2 μsec shaping when used with Canberra Model 2037A Edge/Crossover Timing Single Channel Analyzer.
OVERLOAD RECOVERY - UNIPOLAR (BIPOLAR) output recovery to within ± 2% (1%) of full scale output from X1000 overload in 2.5 (2.0) non-overloaded pulse widths, at full gain, any shaping time constant and pole-zero cancellation properly set.
NOISE CONTRIBUTION - $\leqslant 3.2\ \mu V$ true RMS UNIPOLAR (7.1 μV BIPOLAR) output referred to input, 3 μsec shaping and amplifier gain $\geqslant 100$.
PULSE SHAPING - near-Gaussian shape: one differentiator (two for bipolar), two active filter integrators; UNIPOLAR time to peak: 2.35X shaping time; pulse width: 7.3X shaping time; BIPOLAR time to crossover: 2.8X shaping time, time to peak, pulse width and crossover times measured at 0.1% of full scale output; 1 μsec SHAPING center frequency: 150 kHz; band width: 180 kHz; f_C and BW for other shaping are multiples of that given for 1 μsec.
RESTORER - *active gated.*
* **SPECTRUM BROADENING** - the FWHM of a Co-60 1.33 MeV gamma peak for an incoming rate of 2 kcps to 100 kcps and a 9 volt pulse height will typically change less than 14% for 2 μsec shaping, AUTO Restorer Rate, AUTO Restorer Threshold and ASYM Restorer Mode.
COUNT RATE STABILITY - the peak position of a Co-60 1.33 MeV gamma peak for an incoming count rate of 2k cps to 100k cps and a 9 volt pulse height will typically shift less than 0.024% for 2 μsec shaping, AUTO Restorer Rate, AUTO Restorer Threshold and ASYM Restorer Mode.
* Note: These results may not be reproducible if associated detector exhibits an inordinate amount of long rise time signals.

POWER REQUIREMENTS

+24V dc	— 110 mA	+12V dc	— 115 mA
- 24V dc	— 145 mA	- 12V dc	— 60 mA

CONNECTORS

All signal connectors are BNC type.
PREAMP POWER - rear panel, Amphenol, type 17-10070.

PHYSICAL

SIZE - standard double-width NIM module 2.70 x 8.71 inches (6.85 x 22.13 cm) per TID-20893 (rev.).
NET WEIGHT - 2.9 lbs. (1.3 kgs).
SHIPPING WEIGHT - 5.0 lbs. (2.3 kgs).

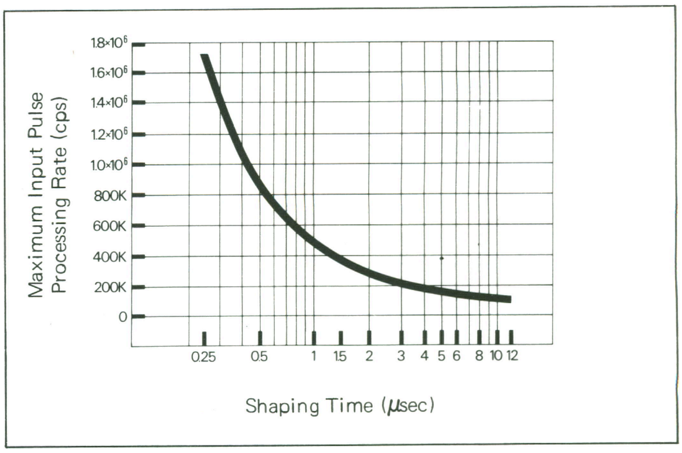
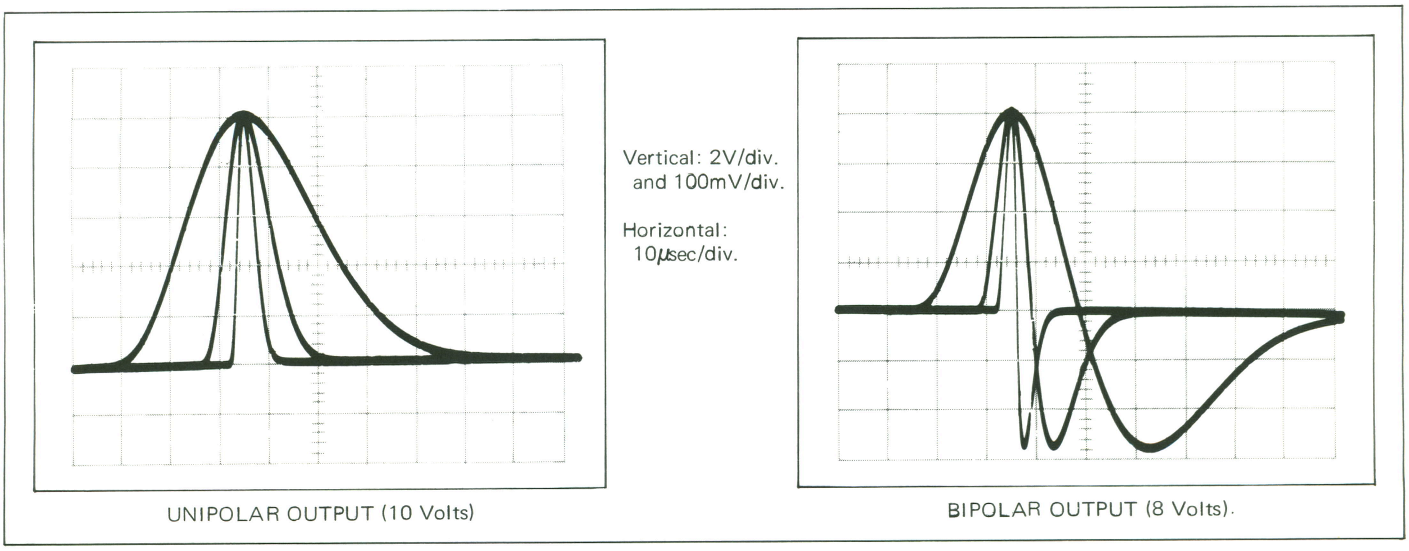


Figure 3.
Typical Model 2021 Maximum Input Pulse Processing Rate verses shaping time constant.

* Maximum Input Pulse Processing Rate: Maximum amplifier input count rate (pulses per second) for which the amplifier's DC restorer maintains the baseline at reference ground.


Vertical: 2V/div. and 100mV/div.

Horizontal: 10μsec/div.

UNIPOLAR OUTPUT (10 Volts)

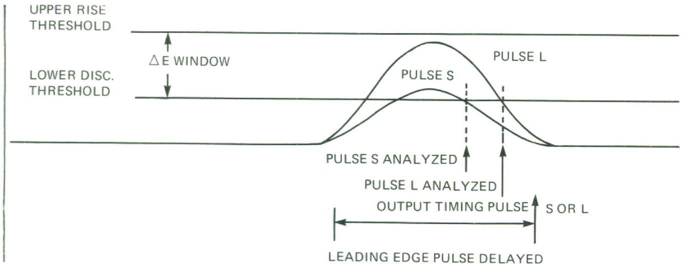
BIPOLAR OUTPUT (8 Volts).

Figure 4.
Model 2021 SHAPING selected for 12, 4 and 1.5 μsec.

SCA INTRODUCTION

The single channel analyzer (SCA) or discriminator is the instrument in a nuclear measurement system often called on to measure the energy of the detected particle which is represented by the amplitude of the resultant output pulse. Introducing this output directly to a counting device, a ratemeter or scaler, with no discrimination on the amplitude of the pulses to the counter, would give uncertain results due to the always present, albeit low level, noise content. If the measurement desired is the gross number of particles detected, a discriminator, set to pass only those pulses with amplitude above a fixed threshold, will insure that only detected nuclear events are counted. The measurement made is simply the fact that the event exceeded a desired threshold and, once made, the discriminator need not preserve the original pulse. It may now generate a standardized output — a pulse certain to be acted on by other instruments appropriate to the measurement. Referred to as "logic" signals, the NIM Standard includes two such signal standards; a "SLOW" positive 8V signal and a "FAST" negative 16mA current pulse. As their names imply, each is optimized to provide measurement certainty as required. In addition, noting the increasing use of TTL logic levels in test and measurement instrumentation, Canberra has incorporated provisions for TTL outputs on newer instruments.

The single channel analyzer permits the discrimination of not only pulses below a certain amplitude but those above another upper threshold as well, allowing the measurement of only those events occurring in a selectable energy window. For convenience, the upper threshold may be defined and set as a ΔE window value which rides above the discriminator threshold E setting. Further, E may be controlled from an external voltage level by an SCA Sweep to drive the window across a selected energy range while the energy spectrum which results is recorded.



The Canberra Model 2030 Single Channel Analyzer provides separate logic signal outputs for pulses which exceed the lower level discriminator (LLD) and for those which exceed the upper level discriminator (ULD). In addition to the SCA output these may be used together or individually in a wide variety of applications such as in distinguishing between α and β particles when used with a proportional counter biased for the β plateau, an α - β plastic detector or any dual particle/dual energy detector.

Of paramount importance in the design of the single channel analyzer or discriminator is the accuracy and stability of the threshold detection. Canberra's use of linear and digital integrated circuits and careful attention to stabilization of the incoming signal insures that offsets, count rate related inaccuracies, and drift are minimized. The Model 2030 Single Channel Analyzer, for example, guarantees discriminator stability of better than ±0.005% of full scale over a 0 to 50°C range.

Timing single channel analyzers extend the measurement one additional step. Beyond permitting the selection of only those pulses representative of a specific energy window in the spectrum, the timing SCA generates its output logic pulse timed to mark the occurrence of the event. Such timing is required when further analysis involving the coincidence/anticoincidence of the event or discrimination of the pulse shape are required.

As is evident from the figure, amplitude discrimination results in an output with timing dependent upon the amplitude and shape of the pulse and therefore not acceptable for timing measurements.

For those applications where both energy constraints and the precise timing of successive pulses is important, the Timing Single Channel Analyzer provides the necessary measurement tool. The TSCA combines the energy discriminator functions of the conventional SCA described above with a timing analyzer keyed to gate its logic outputs at a point that is stabilized in time for wide variations in the amplitude of the analog input pulse. The variance in timing due to amplitude fluctuations is called "walk".

There are three principal methods of timing discrimination used, each optimized for a specific input pulse condition, and each providing commensurate walk behavior, The Model 2035A derives timing from a constant fraction of the input pulse height, a method which serves best with unipolar Gaussian pulses from spectroscopy amplifiers. The Model 2037A offers both low level leading edge timing for fast shaped input pulses from scintillation detectors, and crossover timing for either bipolar amplifier signals or from double delay line (DDL) signals such as from our Model 1411A. The choice of technique depends as much on user familiarity and preference as on the overlapping areas of performance.

The paramount requirement for all three types of instruments in this category is stability: temperature and time stability of the energy discrimination threshold. In this key parameter, all instruments in the Canberra 2030 series excel, with an average temperature stability of better than ±50 ppm/°C.

DESIGN TRADEOFFS

To accommodate high count rate signals, all instruments in the Canberra 2030 series employ direct coupled discriminator inputs. While this approach improves performance to the point that the restorer of the main shaping amplifier becomes the limiting factor in precise high rate counting, it does require that the DC offset of the amplifier be taken into account in exploiting the full dynamic range of these instruments.

PERFORMANCE FEATURES

As mentioned above, stability of the discriminator threshold is the hallmark of the Canberra 2030 series. For user convenience, all threshold controls use 10 turn dial potentiometers calibrated to read the reference voltage directly. An expanded 10% window (ΔE) range is also provided on the Model 2030, 2031, 2035A and 2037A. The Model 2030 and 2035A have front panel LED indicators which may be used instead of an oscilloscope if desired in setting the LOWER LEVEL (E) control just above the main shaping amplifier's noise level for wide range counting.

External LLD reference inputs are provided on both the Model 2030 and 2035A, and may be added as options to any of the Canberra 2030 series.

Positive logic pulse output signals in this series have been made user adjustable to permit maximum flexibility in interfacing all types of new and old instruments. The instruments are shipped with socketed resistors which limit the output voltage pulse to +5V nominal for interfacing common TTL level inputs on current instruments. If desired, the resistor is simply removed, and a +8V output pulse is available for older instruments with higher input thresholds. All logic outputs are source matched to 50Ω to ensure that ringing and consequent multiple counting does not occur, and all output connectors are of the isolated BNC type so that fast pulse currents do not run through the instrument or NIM Bin chassis.

The new Model 2035A and 2037A TSCA's also feature a useful pileup rejection logic which prevents ambiguous event timing or energy discrimination for the constant fraction and crossover timing modes.

More advanced timing instruments designed to operate from preamp output pulses directly using ARC timing and constant fraction derivation techniques are discussed in the TIMING section of this catalog. The Preview Chart which follows will help the user select the analyzer best suited to his requirements.

CANBERRA SCA/DISCRIMINATOR PREVIEW CHART

MAXIMUM FLEXIBILITY, PRECISION SCA MODEL 2030	Stability ≤.005%/°C of F.S.	Pulse Pair Resolution ≤0.65μs	Window 1V/.10V	Outputs LLD, ULD, SCA	Comments LED Monitor
GENERAL PURPOSE SCA 2031	Stability ≤.005%/°C of F.S.	Pulse Pair Resolution ≤0.65μs	Window 1V/10V	Outputs SCA	Low cost
PRECISION TIMING SCA 2035A	Stability ≤.005%/°C of F.S.	Cross-over Walk ±2ns @ 10:1	for 0.5μsec. shaping	Delay 0.1 - 1.1μsec 1 - 11μsec	Constant fraction
GENERAL PURPOSE TIMING SCA 2037A	Stability ≤.005%/°C of F.S.	Cross-over Walk ±4ns @ 10:1 ±8ns @ 50:1	Leading Edge Walk ±40nsec @ 10:1 ±100nsec @ 50:1	Delay 0.1 - 1.1μsec 1 - 11μsec	Low cost
DISCRIMINATORS DISCR. MODEL 2032	Stability ≤.005%/°C of F.S.	Pulse Pair Resolution ≤0.65μsec		Outputs discriminator	Comments Dual disc.

Model 2030
Single Channel Analyzer

Features

- Independent ULD, LLD, and SCA outputs
- Precise threshold discrimination
- Exceptional stability - DC coupled input
- External baseline sweep input
- Dynamic range 1000:1
- LLD monitored by LED display
- Source matched logic outputs

Description

The Canberra Model 2030 analyzes the peak amplitude of energy pulses from nuclear pulse shaping amplifiers, and generates its primary logic output (SCA) for input analog pulses between the levels referenced by the LOWER LEVEL (E) and WINDOW (△E) front panel ten-turn controls. Auxiliary outputs from the Lower Level Discriminator (LLD) as set by (E), and the Upper Level Discriminator (ULD) as set by (E + △E) are also provided. Timing of these logic outputs is set as the trailing edge of the input signal crosses the (E) reference.

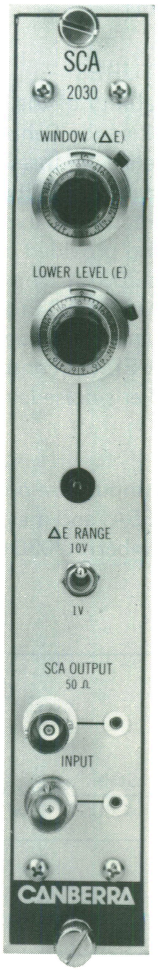
The several outputs may be used together or individually to assist in a wide variety of applications from simple noise removal, to extraction of a narrow energy range from a wide spectrum of signals for energy analysis. The sharp, precise threshold discrimination levels are exceptionally stable (drift less than ±0.005%/°C, full scale). The DC coupled input allows excellent baseline stability limited only by the shaping amplifier's restorer. These significant features permit excellent amplitude discrimination, even in high count rate spectra.

The LOWER LEVEL (E) threshold is calibrated by reference to the regulated NIM supply voltages, and is usable over the range from +0.01VDC to +10.0VDC. Linearity of control is limited only by the specified ±0.25% maximum nonlinearity of the front panel potentiometer. A front panel mounted LED is useful in visually monitoring the setting of the LOWER LEVEL (E) reference just above the shaping amplifier's noise level (the LED will fade off).

The WINDOW (△E) threshold is also calibrated by reference to the regulated NIM supply voltages, and is usable over the range from the LOWER LEVEL (E) setting to +10.0VDC. A front panel △E RANGE switch allows use of a 1.0 volt full scale range for very fine adjustments of the desired window.

An external lower level discriminator (LLD) input on the rear panel may be used in lieu of the front panel control for applications requiring a ratioed or sweeping baseline reference over the energy range. This input requires a positive polarity reference voltage, and is linear over the full scale of 0 to +10.0VDC. A locking toggle switch is used to select this input.

All output logic signals are positive logic, and are adjustable in peak amplitude for compatibility with interfacing instruments. All outputs are source matched with 50 ohm series resistive terminations to prevent ringing due to reflections on unterminated cables, and the resulting multiple counting frequently experienced. The instrument is shipped with a socketed resistor which limits the output to +5V nominal (open circuit) for direct interface with common TTL circuitry. The user may remove the resistor (1 for each output) to obtain a +8V nominal open circuit voltage for instruments requiring the NIM pulse level, or +4V nominal into the 50 ohms load termination which some other instruments provide. This flexibility allows the user to adapt the output signal to his needs without risking the problem encountered with improperly driven cables. Load end terminations are not necessary.



Careful attention has been paid to minimize reflections of the fast logic pulses back onto the analog input. Thus all logic outputs are isolated from chassis to prevent circulating pulse currents in the instrument BIN.

Specifications

INPUTS

SIGNAL INPUT - accepts +0.01 to +10.0VDC, unipolar or bipolar (positive lobe leading) pulses from shaping amplifier. Input impedance 1K ohms. Shaping time constant range 0.1 to 20 microseconds. Front and Rear Panel BNC's

EXTERNAL LLD REFERENCE - accepts 0 to +10.0VDC. Input impedance 1K ohms. Rear Panel BNC

OUTPUTS

SCA - positive logic +5V nominal pulse amplitude. Adjustable to +8V nominal pulse by removing socketed resistor. Output impedance 50 ohms. Pulse width 0.5 microseconds nominal; rise time and fall time less than 25 nanoseconds. Front and Rear Panel BNC's

ULD - same characteristics as SCA. Rear Panel BNC

LLD - same characteristics as SCA. Rear Panel BNC

Specifications(continued)

CONTROLS

LOWER LEVEL (E) - front panel ten-turn locking dial potentiometer to set lower discriminator threshold level

WINDOW (Δ E) - front panel ten-turn locking dial potentiometer to set window width (upper discriminator threshold level above lower level)

△E RANGE - front panel toggle switch to set full scale range of WINDOW (△E) control as +1.0VDC or +10.0VDC

LLD REF MODE - rear panel locking toggle switch to select INTernal lower level via front panel control, or EXTernal input

INDICATOR

LOWER LEVEL - front panel LED blinks when Lower Level is exceeded

PERFORMANCE

DISCRIMINATOR NONLINEARITY - less than ±0.25% of full scale

DISCRIMINATOR STABILITY - better than ±0.005%/°C (±50 ppm/°C) of full scale, referenced to NIM class A supply +12VDC line

DISCRIMINATOR RANGE - better than 1000:1

DISCRIMINATOR PULSE PAIR RESOLUTION - less than 0.65 microseconds

CONNECTORS

All signal connectors are BNC type

POWER REQUIREMENTS

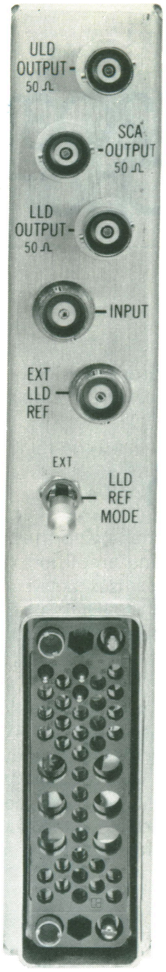
+12VDC	—	155mA
- 12VDC	—	5mA

PHYSICAL

SIZE - standard single width NIM module (1.35 x 8.71 inches) (3.43 x 22.13 cm) per TID-20893 (rev.)

NET WEIGHT - approx. 1.8 lbs. (0.8 kg)

SHIPPING WEIGHT - approx 4.0 lbs. (1.8 kgs)



Model 2031
Single Channel Analyzer

Features

- Dual SCA outputs
- Precise threshold discrimination
- Exceptional stability - DC coupled input
- Dynamic range 500:1
- Source matched logic outputs

Description

The Canberra Model 2031 analyzes the peak amplitude of energy pulses from nuclear pulse shaping amplifiers, and generates its logic output (SCA) for input analog pulses between the levels referenced by the LOWER LEVEL (E) and WINDOW (△E) front panel ten-turn controls. Timing is set as the trailing edge of the input signal crosses the (E) reference.

The SCA output may be used to assist in a wide variety of applications from simple noise removal, to extraction of a narrow energy range from a wide spectrum of signals for energy analysis. The sharp, precise threshold discrimination level is exceptionally stable (drift less than ±0.005%/°C, full scale). The DC coupled input allows excellent baseline stability limited only by the shaping amplifier's restorer. These significant features permit excellent amplitude discrimination, even in high count rate spectra.

The LOWER LEVEL (E) threshold is calibrated by reference to the regulated NIM supply voltages, and is usable over the range from +0.02VDC to +10.0VDC. Linearity of control is limited only by the specified ±0.25% maximum nonlinearity of the front panel potentiometer.

The WINDOW (△E) threshold is also calibrated by reference to the regulated NIM supply voltages, and is usable over the range from the LOWER LEVEL (E) setting to +10.0VDC. A front panel △E RANGE switch allows use of a 1.0 volt full scale range for very fine adjustments of the desired window.

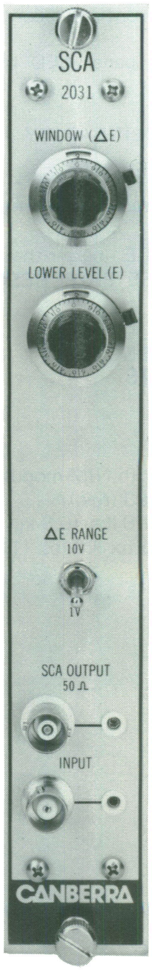
The SCA output logic signal is positive logic, adjustable in peak amplitude for compatibility with interfacing instruments. The output is source matched with a 50 ohm series resistive termination to prevent ringing due to reflections on unterminated cables, and the resulting multiple counting frequently experienced. The instrument is shipped with a socketed resistor which limits the output to +5V nominal (open circuit) for direct interface with common TTL circuitry. The user may remove the resistor to obtain a +8V nominal open circuit voltage for instruments requiring the NIM pulse level, or +4V nominal into the 50 ohm load termination which some other instruments provide. This flexibility allows the user to adapt the output signal to his needs without risking the problem encountered with improperly driven cables. Load end terminations are not necessary.

Careful attention has been paid to minimize reflections of the fast logic pulses back onto the analog input. Thus all logic outputs are isolated from chassis to prevent circulating pulse currents in the instrument BIN.

Specifications

INPUTS

SIGNAL INPUT - accepts +0.02 to +10.0VDC, unipolar or bipolar (positive lobe leading) pulses from shaping amplifier. Input impedance 1K ohms. Shaping time constant range 0.1 to 20 microseconds. Front and Rear Panel BNC's.



OUTPUTS

SCA - positive logic +5V nominal pulse amplitude. Adjustable to +8V nominal pulse by removing socketed resistor. Output impedance 50 ohms. Pulse width 0.5 microseconds nominal; rise time and fall time less than 25 nanoseconds. Front and Rear Panel BNC's.

CONTROLS

LOWER LEVEL (E) - front panel ten-turn locking dial potentiometer to set lower discriminator threshold level.

WINDOW (Δ E) - front panel ten-turn locking dial potentiometer to set window width (upper discriminator threshold level above lower level).

△E RANGE - front panel toggle switch to set full scale range of WINDOW (△E) control as +1.0VDC or +10.0VDC.

Specifications (continued)

PERFORMANCE

DISCRIMINATOR NONLINEARITY - less than ±0.25% of full scale.

DISCRIMINATOR STABILITY - better than ±0.005%/°C (±50ppm%/°C) of full scale, referenced to NIM class A supply +12VDC line.

DISCRIMINATOR RANGE - better than 500:1.

DISCRIMINATOR PULSE PAIR RESOLUTION - less than 0.65 microseconds.

CONNECTORS

All signal connectors are BNC type.

POWER REQUIREMENTS

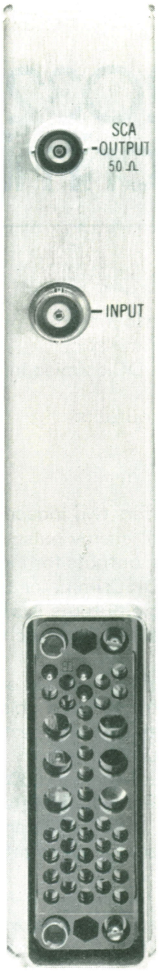
+12VDC — 130mA
-12VDC — 5mA

PHYSICAL

SIZE - standard single width NIM module (1.35 x 8.71 inches) (3.43 x 22.13 cm) per TID-20893 (rev.).

NET WEIGHT - approx. 1.8 lbs. (0.8 kg).

SHIPPING WEIGHT - approx. 4.0 lbs. (1.8 kgs).



Model 2032
Dual Discriminator

Features

- Two independent discriminators in one NIM module
- Precise threshold discrimination
- Exceptional stability - DC coupled inputs
- Dynamic range 250:1
- Source matched logic outputs

Description

The Canberra Model 2032 offers two independent discriminators which analyze the peak amplitude of energy pulses from nuclear pulse shaping amplifiers, and generate logic outputs for input analog pulses exceeding the level referenced by the DISCriminator LEVEL front panel ten-turn controls. Timing of these logic outputs is set as the trailing edge of the input signal crosses the reference set for each.

The logic outputs may be used together or individually to assist in a wide variety of applications from simple noise removal, to extraction of a narrow energy range from a wide spectrum of signals for energy analysis. The sharp, precise threshold discrimination levels are exceptionally stable (drift less than ±0.005%/°C, full scale). The DC coupled input allows excellent baseline stability limited only by the shaping amplifier's restorer. These significant features permit excellent amplitude discrimination, even in high count rate spectra.

The DISCriminator LEVEL threshold is calibrated by reference to the regulated NIM supply voltages, and is usable over the range from +0 04VDC to +10.0VDC. Linearity of control is limited only by the specified ±0.25% maximum nonlinearity of the front panel potentiometer.

The output logic signals are positive logic, and are adjustable in peak amplitude for compatibility with interfacing instruments. The outputs are source matched with 50 ohm series resistive terminations to prevent ringing due to reflections on unterminated cables, and the resulting multiple counting frequently experienced. The instrument is shipped with a socketed resistor which limits the output to +5V nominal (open circuit) for direct interface with common TTL circuitry. The user may remove the resistor (1 for each output) to obtain a +8V nominal open circuit voltage for instruments requiring the NIM pulse level, or +4V nominal into the 50 ohms load termination which some other instruments provide. This flexibility allows the user to adapt the output signal to his needs without risking the problem encountered with improperly driven cables. Load end terminations are not necessary.

Careful attention has been paid to minimize reflections of the fast logic pulses back onto the analog input. Thus all logic outputs are isolated from chassis to prevent circulating pulse currents in the instrument BIN.

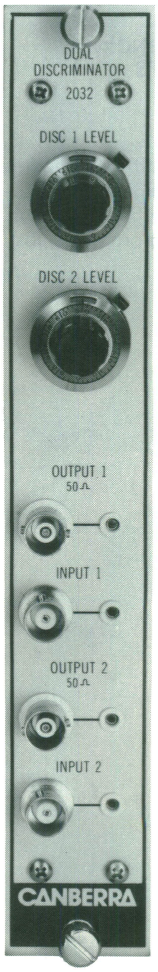
Specifications

INPUTS

INPUT 1, INPUT 2 - accept +0.04 to +10.0VDC, unipolar or bipolar (positive lobe leading) pulses from shaping amplifier. Input impedance 1K ohms. Shaping time constant range 0.1 to 20 microseconds. Front and Rear Panel BNC's

OUTPUTS

OUTPUT 1, OUTPUT 2 - positive logic +5V nominal pulse amplitude. Adjustable to +8V nominal pulse by removing socketed resistor. Output impedance 50 ohms. Pulse width 0.5 microseconds nominal; rise time and fall time less than 25 nanoseconds. Front and Rear Panel BNC's



CONTROLS

DISC 1 LEVEL, DISC 2 LEVEL - front panel ten-turn locking dial potentiometer to set discriminator threshold level

PERFORMANCE

DISCRIMINATOR NONLINEARITY - less than ±0.25% of full scale

DISCRIMINATOR STABILITY - better than ±0.005%/°C (±50ppm/°C) of full scale, referenced to NIM class A supply +12VDC line

DISCRIMINATOR RANGE - better than 250:1

DISCRIMINATOR PULSE PAIR RESOLUTION - less than 0.65 microseconds

CONNECTORS

All signal connectors are BNC type.

POWER REQUIREMENTS

+12VDC	–	120mA
-12VDC	–	5mA

PHYSICAL

SIZE - standard single width NIM module (1.35 x 8.71 inches) (3.43 x 22.13 cm) per TID-20893 (rev.)

NET WEIGHT - approx. 1.8 lbs. (0.8 kg)

SHIPPING WEIGHT - approx. 4.0 lbs. (1.8 kgs)

Model 2035A
Constant Fraction Timing Single Channel Analyzer

Features

- Constant fraction timing derivation
- Dynamic range 400:1
- Pileup rejection logic
- Independent timing ULD, LLD and SCA outputs
- Exceptional stability - DC coupled input
- LLD monitored by LED display
- External gate/strobe input
- Source matched logic outputs to prevent ringing
- External baseline sweep input
- Variable delay of up to 11μsec

Description

The Canberra Model 2035A analyzes the peak amplitude of energy pulses from nuclear pulse shaping amplifiers for compliance with energy levels determined by front panel controls, and generates logic outputs which are time derived from a constant fraction of the input pulse height. The unit thus combines the conventional single channel analyzer function with that of a precise timing analyzer.

The constant fraction technique of timing signal derivation has long been recognized as the optimum approach for analysis of the unipolar signals used in high resolution spectroscopy systems. Until recently, however, it has been difficult to manufacture an accurate, easy-to-use instrument that is free from ambiguous outputs and lives up to the expectations of laboratory users. The Canberra Model 2035A is the product of careful development intended to satisfy exacting needs.

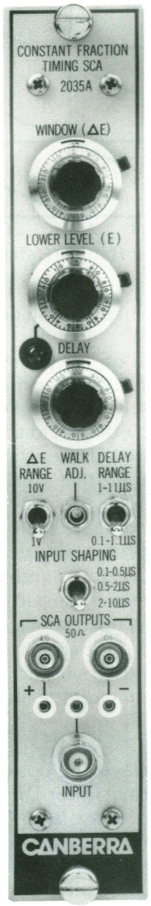
ENERGY

The primary logic output (SCA) is provided as both positive and negative NIM-level pulses for input analog pulses whose peak amplitude is between the levels determined by the LOWER LEVEL (E) and WINDOW (Δ E) front panel ten-turn controls. Auxiliary positive outputs from the Lower Level Discriminator (LLD) as set by the (E) control and from the Upper Level Discriminator (ULD) as set by the sum of the (E) and (Δ E) controls are also provided. Timing of these logic outputs is synchronous as derived by the constant fraction discriminator.

The availability of timing on all outputs should prove especially convenient for simultaneous timing analysis of multiple energy bands. The several outputs may also be used together or individually to assist in a wide variety of conventional applications, from simple noise removal to extraction of a narrow energy range from a wide spectrum for detailed timing and energy analysis.

Energy discrimination in the Model 2035A is sharp, precise and stable (drift less than ±.005%/°C, full scale). The DC coupled input allows excellent baseline stability limited only by the shaping amplifier's restorer. These significant features permit excellent amplitude discrimination, even in high count rate spectra.

The LOWER LEVEL (E) threshold is calibrated by reference to the regulated NIM supply voltages, and is usable in a range from +0.025 to +10.0VDC. Linearity of control is limited only by the specified ±0.25% maximum integral nonlinearity of the front panel potentiometer. A front panel mounted LED is useful in visually monitoring the setting of the LOWER LEVEL (E) reference above the shaping amplifier's noise level (the LED will fade off).



The WINDOW (Δ E) threshold is also calibrated by reference to the regulated NIM supply voltages, and is usable in a range from the LOWER LEVEL (E) setting to +10.0VDC. A front panel Δ E RANGE switch allows use of a 1.0 volt full scale range for very fine adjustments of a small energy window.

An external lower level discriminator input on the rear panel may be used in lieu of the front panel control for applications requiring a ratioed or sweeping baseline reference over the energy range. This input requires a positive voltage, and is linear over the full scale of 0 to 10.0VDC. A locking toggle switch on the rear panel is used to select this input.

TIMING

The constant fraction timing discriminator in the Model 2035A operates on the difference signal between the normal input signal and a delayed facsimile. Three separate internal delays are used to insure optimum walk performance over the specified range of input shaping time constants of the driving amplifier. A front panel INPUT SHAPING switch permits the user to select these delays according to the shaping time constant used.

Description (continued)

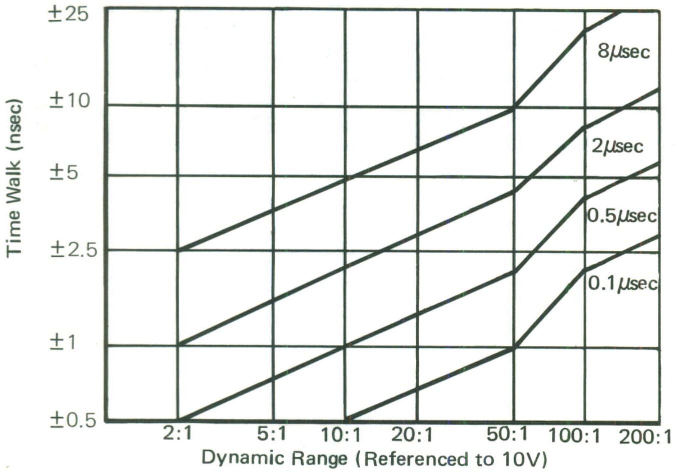


Figure 1: Nominal limits of time walk of SCA output vs. dynamic range for various input pulse shapings (unipolar, near-Gaussian)

One important design feature of the Model 2035A is the pulse lock-out (pileup rejection) logic. First, internal gating prevents the timing cycle (including the front panel selected DELAY) from being initiated on events below the selected LLD threshold and thus minimizes dead time. Events recognized above the ULD are accepted and processed through the full timing cycle so that the ULD can provide timing data. Secondly, the lock-out logic rejects energy pulses which arrive after the first valid signal (i.e., above the LLD) but prior to reset at the end of a normal timing cycle. This prevents a second, possibly higher energy signal from changing the data latches and causing an erroneous output (timed to one event and energy gauged to a second). Thirdly, the lock-out logic prevents timing aberrations due to pileup by responding only to the next full event following a timing cycle instead of the potentially long tail of a pulse arriving at or near the end of one timing cycle. Lockout logic thus eliminates the most common ambiguities, and assures the user of valid data outputs.

The pulse outputs may be delayed by up to 11µsec relative to a prompt output by use of the front panel linear DELAY control. Two ranges are provided: 0.1-1.1µsec added delay, and 1-11µsec. The selected delay and the output pulse width plus reset time, determine the pulse pair resolution under any given circumstances. Optimum performance is about 800nsec unless a shorter positive output pulse is acceptable.

A GATE/STROBE input allows the user to gate the functioning of the Model 2035A, or strobe the energy latches at a selected time. An internal jumper plug permits selection of function (gate, strobe, or normal). In gating, a positive logic level voltage is required to enable the unit. Outputs are then generated per normal constant-fraction timing. In strobing, output pulses are generated coincident with the leading edge of an applied positive logic voltage pulse. The output pulses will contain energy data only (no-timing) based upon the first input pulse processed after the preceding strobed output because of the lock-out logic discussed above.

Positive output logic signals are adjustable in peak amplitude for compatibility with interfacing instruments. The outputs are source-matched with 50 ohm series resistive terminations to prevent ringing due to reflections on unterminated cables, and the resulting multiple counting frequently experienced. The instrument is shipped with socketed resistors for each output which limit the output to +5V nominal (open circuit) for direct interface with common TTL circuitry. The user may remove the resistors as desired to obtain a +8V nominal open circuit voltage for instruments requiring the NIM pulse level, or +4V nominal into the 50 ohm load termination which some other instruments provide. This flexibility allows the user to adapt the output signal to his needs without risking the problems encountered with improperly driven cables and critical timing pulses.

The negative SCA output is a NIM standard 16mA current pulse designed to yield a nominal — 800mV pulse across a 50 ohm load termination. Source matching here again guarantees a clean, stable pulse output even with a load mismatch, if that becomes desirable.

Careful attention has been paid to minimize reflections of the fast logic pulses onto the analog input. Thus all logic outputs are isolated from chassis to prevent circulating pulse currents in the instrument Bin.

Specifications

INPUTS

SIGNAL INPUT - accepts +0.025 to 10.0VDC, unipolar or bipolar pulses from shaping amplifier. DC coupled. Input impedance 1K ohms. Shaping time constant range 0.1 to 10 microseconds. Front and rear panel BNC's. Front panel test point.

EXTERNAL LLD REFERENCE - accepts 0 to +10.0VDC. Input impedance 1K ohms. Rear panel BNC.

GATE/STROBE - accepts +5VDC logic level. Input impedance one TTL load. Rear panel BNC.

OUTPUTS

SCA (+) - positive logic +5V nominal pulse amplitude. Output impedance 50 ohms. Pulse width 0.5 microseconds nominal; rise time and fall time less than 25 nanoseconds. Front and rear panel BNC's. Front panel test point.

SCA (-) - negative logic 16mA current pulse. Output impedance 50 ohms. Pulse width 20 nanoseconds nominal; rise time less than 5 nanoseconds. Front panel BNC. Front panel test point.

ULD - same characteristics as SCA (+). Rear panel BNC.

LLD - same characteristics as SCA (+). Rear panel BNC.

CONTROLS

LOWER LEVEL (E) - front panel ten-turn locking dial potentiometer to set lower discriminator threshold level.

WINDOW (Δ E) - front panel ten-turn locking dial potentiometer to set window width (upper discriminator threshold level above lower level).

DELAY front panel ten-turn dial potentiometer to set delay.

Δ E RANGE - front panel toggle switch to set full scale range of the WINDOW (Δ E) control as +1.0 VDC or +10.0VDC.

DELAY RANGE - front panel toggle switch to set full scale range of the DELAY control as 1.1 microseconds or 11 microseconds.

INPUT SHAPING - front panel toggle switch to select delay line according to input shaping time constant range: 0.1 - 0.5 microseconds; 0.5 - 2 microseconds; 2 - 10 microseconds.

WALK ADJUST - front panel 22 turn screwdriver adjust potentiometer to trim walk behavior over dynamic range used for delay element selected.

LLD REF MODE - rear panel locking toggle switch to select INTernal lower level reference via front panel control, or EXTernal.

GATE/NORMAL/STROBE - internal jumper plug to select gated, normal, or strobed mode. Shipped in NORMAL position.

INDICATOR

LOWER LEVEL - front panel LED blinks when input exceeds Lower Level Discriminator.

PERFORMANCE

DISCRIMINATOR NONLINEARITY - less than ±0.25% integral.

DISCRIMINATOR STABILITY - better than ±0.005%/°C (±50ppm/°C) of full scale, referenced to NIM class A supply +24VDC line.

DISCRIMINATOR RANGE - 400:1.

DELAY NONLINEARITY - less than ±1% of full scale.

DELAY STABILITY - better than ±0.01%/°C (±100ppm/°C) of delay range.

PULSE PAIR RESOLUTION - output pulse width (positive) plus delay selected plus 200 nanoseconds cycle time. Minimum resolving time 800 nanoseconds.

WALK - referenced to 10.0V full scale unipolar input with 0.5 microsecond shaping:

DYNAMIC RANGE	WALK (MAXIMUM)
10:1	±1 nanoseconds
50:1	±2 nanoseconds
100:1	±4 nanoseconds
200:1	±6 nanoseconds

For typical walk behavior with other shaping time constants, see Fig. 1.

Walk beyond a 200:1 range is limited by jitter due to amplifier noise effects. Detector and system noise and other baseline anomalies may restrict usable dynamic range for timing analysis purposes in a given experimental setup to less than those quoted.

CONNECTORS

All signal connectors are BNC type.

POWER REQUIREMENTS

+24VDC —	30mA	+12VDC —	145mA
- 24VDC —	10mA	- 12VDC —	55mA

PHYSICAL

SIZE - standard single width NIM module (1.35 x 8.71 inches), (3.43 x 22.13 cm) per TID-20893 (rev.).

NET WEIGHT - approx. 2.3 lbs. (1.0 kgs)

SHIPPING WEIGHT - approx. 4.0 lbs. (1.8 kgs)

Model 2037A Edge/Crossover Timing Single Channel Analyzer

Features

- Leading edge or crossover type timing derivation
- Dynamic range 100:1
- Pileup rejection logic
- Exceptional stability - DC coupled input
- Positive and negative timing SCA outputs
- Source matched logic outputs
- Variable delay of up to 11μsec

Description

The Canberra Model 2037A analyzes the peak amplitude of energy pulses from nuclear pulse shaping amplifiers for compliance with energy levels determined by front panel controls, and generates logic outputs which are time derived by the leading edge or crossover techniques. The unit thus combines the conventional single channel analyzer function with that of an excellent but economical timing analyzer.

The leading edge timing technique finds best application to fast-shaped unipolar signals of a fairly narrow energy (pulse height) range. The crossover technique exploits the amplitude insensitive zero voltage crossing of a bipolar pulse to provide stable timing reference for a broad energy range. A front panel MODE switch allows selection of either timing derivation.

ENERGY

The logic output (SCA) is provided as both positive and negative NIM-level pulses for input analog pulses whose peak amplitude is between the levels determined by the LOWER LEVEL (E) and WINDOW (Δ E) front panel ten-turn controls.

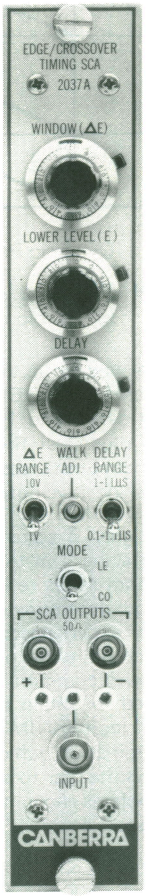
Energy discrimination in the Model 2037A is sharp, precise and stable (drift less than ±.005/%/°C, full scale). The DC coupled input allows excellent baseline stability limited only by the shaping amplifier's restorer. These significant features permit excellent amplitude discrimination, even in high count rate spectra.

The LOWER LEVEL (E) threshold is calibrated by reference to the regulated NIM supply voltages, and is usable in a range from +0.1 to +10.0VDC. Linearity of control is limited only by the specified ±0.25% maximum integral nonlinearity of the front panel potentiometer.

The WINDOW (Δ E) threshold is also calibrated by reference to the regulated NIM supply voltages, and is usable in a range from the LOWER LEVEL (E) setting to +10.0VDC. A front panel Δ E RANGE switch allows use of a 1.0 volt full scale range for very fine adjustments of the desired energy window.

TIMING

For the leading edge mode, a true low level leading edge technique is employed to minimize timing jitter. To simplify setup and adjustment the threshold level for the leading edge timing discriminator is set to track the LOWER LEVEL (E) control at 50%, up to a limit of 200mVDC. For reasonably large input pulse heights, then, timing is referenced to the 200mVDC level. To simplify adjustment of timing dwell for the risetime of the input pulse, that function has been incorporated in an extended range DELAY control. The user can simply set the selected delay for the known time-to-peak of the input pulse (or at least 2X the shaping time constant used in a near-Gaussian pulse) without the need for tedious oscilloscope trimming.



For the crossover mode, a bridge circuit timing discriminator is used to sense the true zero crossing of the bipolar energy pulse as superimposed on a DC offset of up to ±100mVDC. A front panel WALK ADJustment is provided to trim walk over the dynamic range used.

One important design feature of the Model 2037A is the pulse lock-out logic for the crossover mode. First, internal gating prevents the timing cycle (including the front panel selected DELAY) from being initiated on events below the selected LLD threshold, and thus minimizes dead time. Events recognized above the ULD are accepted and processed through the full timing cycle so that the ULD can provide timing data. Secondly, the lock-out logic rejects energy pulses which arrive after the first valid signal (i.e., above the LLD) but prior to reset at the end of a normal timing cycle. This prevents a second, possibly higher energy signal from changing the data latches and causing an erroneous output (timed to one event and energy gauged to a second). Thirdly, the lock-out logic prevents timing aberrations due to pileup by responding only to the next full event following a timing cycle instead of the potentially long tail of a pulse arriving at or near the end of one timing cycle. These features enhance the performance of the unit in the crossover mode by eliminating the pulse ambiguities described. Unfortunately the same lock-out logic can not be used to prevent potentially erroneous outputs in the leading edge mode.

Description(continued)

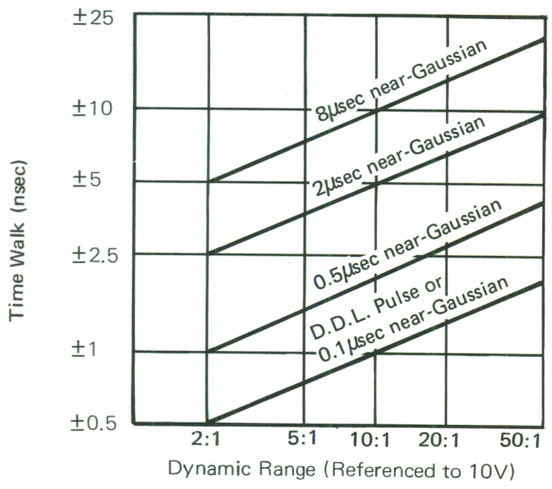


Figure 1: Nominal limits of time walk of SCA output vs. dynamic range for various input pulse shapings (bipolar).

The pulse outputs may be delayed by up to 11μsec relative to a prompt output by use of the front panel linear DELAY control. Two ranges are provided: 0.1-1.1μsec added delay, and 1-11μsec. The selected delay, and the output pulse width plus reset time, determine the pulse pair resolution under any given circumstances. Optimum performance is about 800nsec unless a shorter positive output is acceptable.

The positive output logic signal is adjustable in peak amplitude for compatibility with interfacing instruments. The output is source-matched with a 50 ohm series resistive termination to prevent ringing due to reflections on unterminated cables, and the resulting multiple counting frequently experienced. The instrument is shipped with a socketed resistor which limits the output to +5V nominal (open circuit) for direct interface with common TTL circuitry. The user may remove the resistor as desired to obtain a +8V nominal open circuit voltage for instruments requiring the NIM pulse level, or +4V nominal into the 50 ohm load termination which some other instruments provide. This flexibility allows the user to adapt the output signal to his needs without risking the problems encountered with improperly driven cables and critical timing pulses.

The negative SCA output is a NIM standard 16mA current pulse designed to yield a nominal −800mV pulse across a 50 ohm load termination. Source matching here again guarantees a clean, stable pulse output even with a load mismatch.

Careful attention has been paid to minimize reflections of the fast logic pulses onto the analog input. Thus all logic outputs are isolated from chassis to prevent circulating pulse currents in the instrument Bin.

Specifications

INPUTS

SIGNAL INPUT - accepts +0.1 to 10.0VDC, unipolar or bipolar (positive lobe leading) pulses from shaping amplifier. DC coupled, input impedance 1K ohms. Shaping time constant range 0.1 to 10 microseconds. Front panel BNC. Front panel test point.

OUTPUTS

SCA (+) - positive logic +5V nominal pulse amplitude. Adjustable to +8V nominal pulse by removing socketed resistor. Output impedance 50 ohms. Pulse width 0.5 microseconds nominal; rise time and fall time less than 25 nanoseconds. Front panel BNC. Front panel test point.

SCA (-) - negative logic 16mA current pulse output. Output impedance 50 ohms. Pulse width 20 nanoseconds nominal; rise time less than 5 nanoseconds. Front panel BNC. Front panel test point.

CONTROLS

LOWER LEVEL (E) - front panel ten-turn locking dial potentiometer to set lower discriminator threshold level.

WINDOW (Δ) - front panel ten-turn locking dial potentiometer to set window width (upper discriminator threshold level above lower level).

DELAY - front panel ten-turn locking dial potentiometer to set delay of outputs.

ΔE RANGE - front panel toggle switch to set full scale range of the WINDOW (ΔE) control as +1.0VDC or +10.0VDC.

DELAY RANGE - front panel toggle switch to set full scale range of the DELAY control as 1.1 microseconds or 11 microseconds added delay.

MODE - front panel toggle switch to select timing derivation from leading edge or crossover of input pulse.

PERFORMANCE

DISCRIMINATOR NONLINEARITY - less than ±0.25% of full scale.

DISCRIMINATOR STABILITY - better than ±0.005%/°C (±50ppm/°C) of full scale, referenced to NIM class A supply +24VDC line.

DISCRIMINATOR RANGE - 100:1.

DELAY NONLINEARITY - less than ±1% of full scale.

DELAY STABILITY - better than ±0.01%/°C (±100ppm/°C) of delay range.

PULSE PAIR RESOLUTION - output pulse width (positive) plus the DELAY selected plus 200 nanoseconds cycle time. Minimum resolving time 800 nanoseconds.

WALK - referenced to 10.0V full scale input,

A) For leading edge mode: with risetime less than 100 nanoseconds:

DYNAMIC RANGE	WALK (MAXIMUM)
10:1	±40 nanoseconds
50:1	±100 nanoseconds

B) For crossover mode: with bipolar input pulse with 0.5 microsecond near-Gaussian shaping:

DYNAMIC RANGE	WALK (MAXIMUM)
10:1	±2 nanoseconds
50:1	±4 nanoseconds

C) For crossover mode, with DDL shaped input (1μsec delay line, rise time less than 100nsec):

DYNAMIC RANGE	WALK (MAXIMUM)
10:1	±1 nanoseconds
50:1	±2 nanoseconds

For typical walk behavior with other shaping time constants, see Fig. 1.

Walk beyond a 50:1 range is limited by jitter due to amplifier noise effects. Detector and system noise, and other baseline anomalies, may restrict usable dynamic range for timing analysis purposes in a given experimental setup to less than those quoted above.

CONNECTORS

All signal connectors are BNC type.

STANDARD OPTIONS AVAILABLE FOR REAR PANEL

- Timing SCA Output
- Timing ULD Output
- Timing LLD Output
- Signal Input
- External LLD (Baseline Sweep) Input
- Gate Input
- Strobe Input

POWER

+24VDC	30mA	+12VDC	145mA
-24VDC	10mA	-12VDC	55mA

PHYSICAL

SIZE - standard single width NIM module (1.35 x 8.71 inches), (3.43 x 22.13 cm) per TID-20893 (rev.).

NET WEIGHT - approx. 1.9 lbs. (0.9 kg).

SHIPPING WEIGHT - approx. 4.0 lbs. (1.8 kgs).

TIMING INTRODUCTION

A timing instrument marks or measures the precise occurrence of nuclear events. In practice, the release of electrons which result from the detector's absorption of a particle's energy, occurs after the actual event; how long after is dependent upon the detector and how it is employed. The electronics processing this output further modifies its characteristics. All of these factors must be accounted for, in addition to the problem of noise, when making precise and highly resolved timing measurements.

Timing modules provide the nuclear experimenter with a set of measurement tools aimed at precise analysis of the timing intervals between nuclear events. Analysis here is commonly performed on unshaped signals in efforts to resolve sub-nanosecond relationships, as contrasted with techniques using the outputs of spectroscopy amplifiers through a timing SCA, where resolution is limited to the 1 to 10 nanosecond range. The latter area is commonly termed, "slow timing," to distinguish it from the "fast timing" analysis discussed here.

The primary limitations to fast timing resolution center on the sources of timing error: jitter and walk. Jitter is a timing uncertainty or variation caused by noise effects on the pulse being analyzed (random noise riding on the signal changes the absolute point at which a discriminator responds). Walk is the variation in timing as influenced by the dynamic range of the amplitude of the input signal being analyzed, or the rise time deviations caused by the charge collection process in the detectors.

Timing inaccuracies due to "walk" become the major problem in deriving timing from a unipolar pulse. To overcome the lack of a well-defined signal slope at the baseline from which a stable timing mark may be derived, "Constant Fraction" or "Amplitude/Rise time Compensation" (ARC) timing techniques are used.

Similar to the example of a delay line amplifier, Constant Fraction timing involves the inversion, delay and recombination of the signal to create a zero crossing mark. However, rather than adding the inverted and delayed signal to the original to achieve cancellation, some fractional part of the original is used to insure baseline crossover. As is evident in Figure 1 the crossover point is independent of amplitude of the input signal. The Canberra Model 1428A Constant Fraction Discriminator operates on this principle.

Solid-state detectors, primarily large volume Ge(Li) detectors, produce rise times which vary, dependent upon the location the gamma ray enters and is absorbed in the detector's volume. Such a pulse rise time variation cannot be accommodated by Constant Fraction timing, which requires that all pulses be identical in shape.

ARC timing differs from Constant Fraction timing in the amount of pulse delay employed and is tolerant of rise time changes if the point of change occurs after the delay period, which is set very short. Since this is the case with all detectors, ARC timing will provide the best possible results with solid state or scintillation detectors.

The Model 1428A accepts negative polarity inputs from scintillators or other detectors at a higher signal level and offers both Constant Fraction timing derivation (with or without rise time rejection) and Leading Edge timing derivation. This instrument offers a wide range variable threshold but fixed rise time rejection. Sub-nanosecond timing resolution is achieved with plastic scintillators with the 1428A.

Coincidence applications of timing generally fall into two categories: fast timing coincidence or slow energy coincidence; generally, applications often involve combinations of the two types. The reason for the distinction is primarily due to the circuit design differences required to resolve time differences above or below 100nsec. Coincidence units operate on the coincidence or anti-coincidence of two or more inputs within a specific resolving time and generate a logic pulse only when the input conditions are met. Stability and user flexibility are the major attributes, and Canberra has developed a complete line of units to satisfy virtually any coincidence requirements.

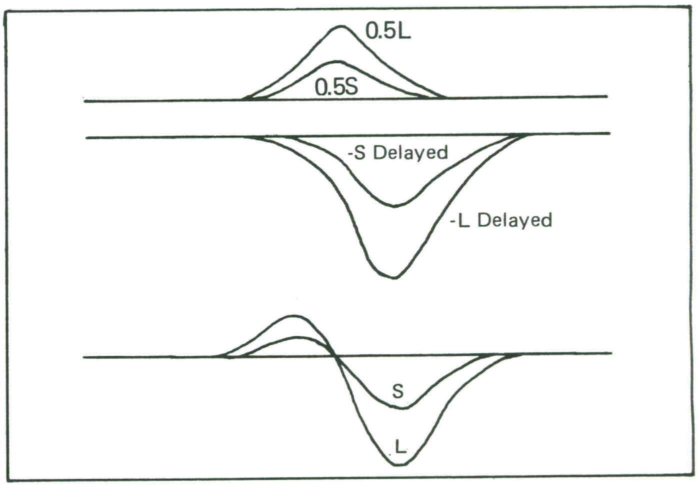


Figure 1.

Gamma spectroscopy can benefit greatly from the application of coincidence techniques. One major problem hampering the analysis of gamma spectra results from Compton background. By surrounding the high energy resolution Ge(Li) detectors with a fast scintillator, which is shielded from the gamma source, any coincidence between outputs from both detectors must be due to Compton scattering. By connecting the output of the surrounding scintillator in anti-coincidence with the Ge(Li), much of the Compton scattering can, in effect, be cancelled out.

The Time Analyzer is an essential component in many timing applications and an invaluable aid in all. At the heart of the Time Analyzer is a time to amplitude converter which produces an output pulse with amplitude directly proportional to the time between two specific events. The output of the Time Analyzer may be treated in the same manner as energy pulses to derive information concerning the time distribution, resolution or correlation of events. The addition of a timing single channel analyzer to the output pulses allows selection of a time range or total resolving time.

The Model 2043 Time Analyzer includes the single channel analyzer on the time difference output and provides monitoring pulse outputs for the start and stop pulses. The Model 2044 is a single NIM width unit with only the time difference output.

The Model 2110 Timing Filter Amplifier is useful for matching preamplifier signals to timing circuits. It is completely direct coupled and features variable gain with selectable differentiation and integration time constants to allow an easy means of optimizing fast timing.

The Model 2035A and 2037A Timing SCAs are also frequently used in timing and coincidence applications. These are described in the SCA section, and typical uses are shown in the Application and Technical Reference section.

CANBERRA TIMING INSTRUMENTS PREVIEW CHART

APPLICATION: COINCIDENCE

MODEL	No. of Inputs	Resolving Time	Type
1446	5 pos ** (any can be anti-coin)	.1-2μs	Universal
2040	4 pos (1 anti-coin)	10-100ns, 0.1-1.0μs	General Purpose
2144A	5 pos/neg*	<10ns	Fast/Slow

*Logical And, Or: FAN-IN, FAN-OUT, FAST-COIN or ANTI-COIN
**No. of Coincidence events may be selected

APPLICATION: OPTIMUM HIGH COUNT RATE TIMING

MODEL 1428A CONSTANT FRACTION DISCRIMINATOR

Input: Photomultiplier or Timing Amplifier

Stability: 0.1%/°C for 24 hours

Walk: <110ps for 100:1

Delay: External cable; 1.5ns/foot

Outputs: 2 neg., 1 pos. logic

APPLICATION: TIME-AMPLITUDE CONVERSION/ANALYSIS

MODEL 2043, 2044 TIME ANALYZERS

Range: 15; 20-1000nsec. F.S.

Resolution: <7ps FWHM, 50ns range:
<0.01% FS all other ranges

Stability: <±10ps/°C, 50ns range;
<0.01%/°C all other ranges

SCA Walk: (2043 only) None, with respect to TAC output

Nonlinearity: <±0.1 integral, ±2% differential

Internal gating logic prevents over range or ambiguous outputs.

APPLICATION: PULSE SHAPING FOR TIMING

MODEL 2110 TIMING FILTER AMPLIFIER

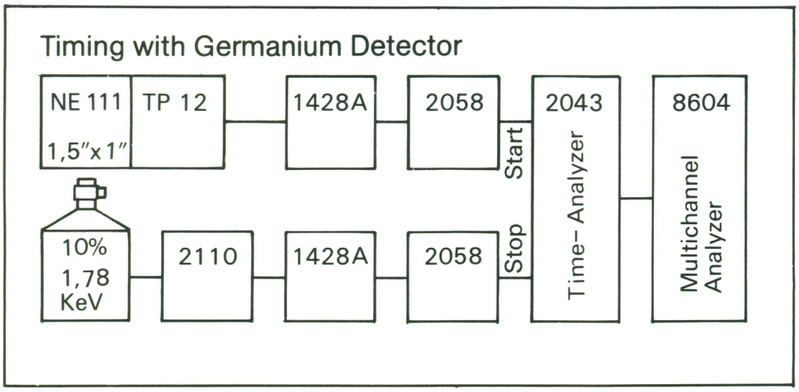
Input: Direct from detector

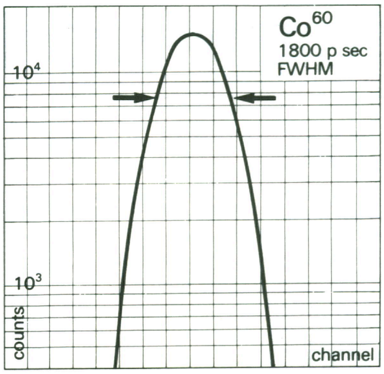
Gain: 2 to 100, coarse and fine controls,
plus input attenuator

Shaping: 10 to 200 nanosecond differentiation and
integration time constants

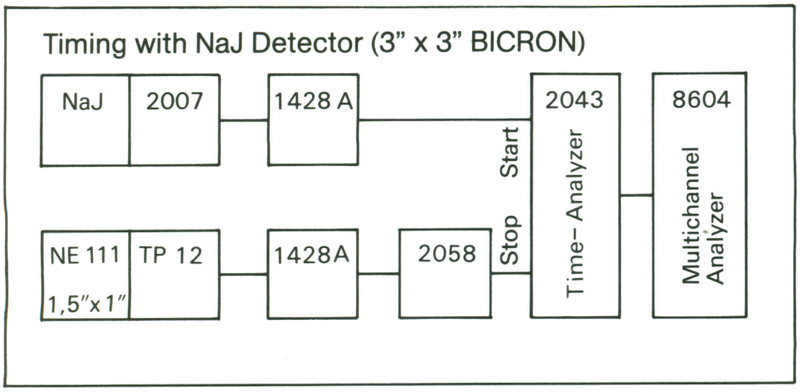
Outputs: 1, pos. or neg.

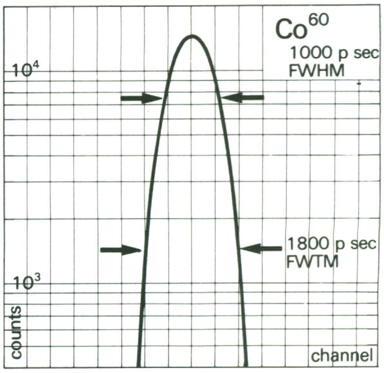
Timing with Germanium Detector


NE 111
TP 12
1,5"x 1"
1428A
2058
2043
8604
Start
Time-Analyzer
Multichannel Analyzer
10%
1,78 KeV
2110
1428A
2058
Stop

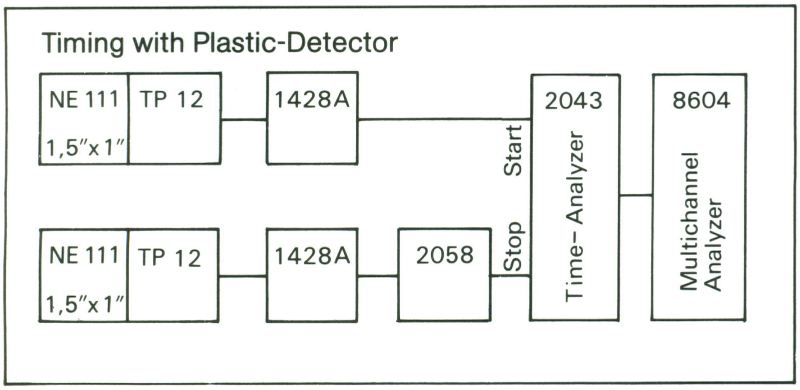


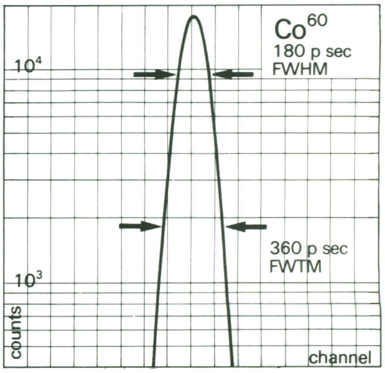
Timing with NaJ Detector (3" x 3" BICRON)


NaJ
2007
1428 A
2043
8604
Start
Time-Analyzer
Multichannel Analyzer
NE 111
TP 12
1,5"x 1"
1428A
2058
Stop

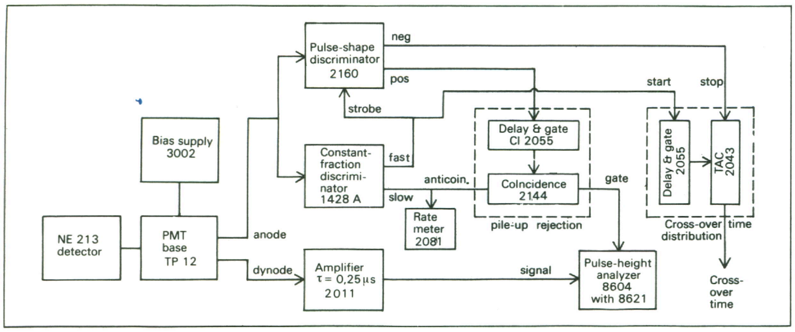


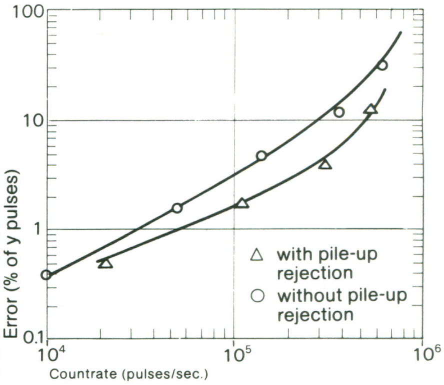
Timing with Plastic-Detector


NE 111
TP 12
1,5"x 1"
1428A
2043
8604
Start
Time-Analyzer
Multichannel Analyzer
NE 111
TP 12
1,5"x 1"
1428A
2058
Stop



Neutron Spectrometer – Electronic with Pile-up rejection


Pulse-shape discriminator 2160
neg
pos
strobe
start
stop
Bias supply 3002
Constant-fraction discriminator 1428 A
fast
anticoin.
slow
Delay & gate CI 2055
Coincidence 2144
gate
Delay & gate 2055
TAC 2043
Rate meter 2081
pile-up rejection
Cross-over time distribution
NE 213 detector
PMT base TP 12
anode
dynode
Amplifier τ = 0,25 μs 2011
signal
Pulse-height analyzer 8604 with 8621
Cross-over time



Model 1428A
Constant Fraction Discriminator

Features

- 1000: 1 dynamic range
- DC coupling throughout for high count rate capability (to 50MHz)
- 3 operating modes
- Walk less than ±125psec for 100:1 dynamic range
- 3 independent simultaneous outputs

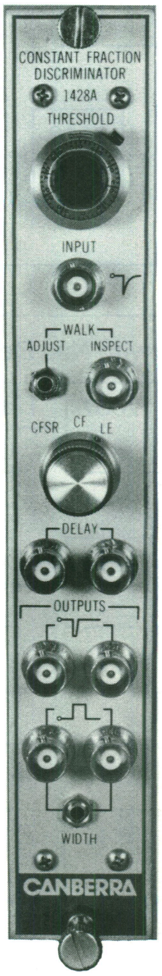
Description

The Model 1428A is a fully DC coupled Constant Fraction Discriminator featuring a dynamic range of up to 1000: 1. This unit provides optimum time resolution for Germanium detectors in the Constant Fraction with Slow Risetime reject (CFSR) mode, and for faster detectors in basic Constant Fraction timing (CF) or Leading Edge timing (LE) according to the needs of the experiment.

The Model 1428A accepts negative polarity pulses to its 50 ohm terminated DC coupled input. The constant fraction composite signal is formed by the algebraic sum of a direct, attenuated signal path (ratio set to 25%, but user changeable) and a delayed, unattenuated path. The delay time is user selected according to the propagation delay of a cable connected between 2 front panel mounted BNC's. Optimum selection of this external delay provides full compensation for timing distortions due to both amplitude and rise time variations in the input signal.

Four simultaneous, independent output signals are provided. The two positive NIM voltage outputs are adjustable in width; the width duration sets the internal dead time as required to suppress spurious outputs due to input signal anomalies. The two independent negative NIM current outputs are derived as fixed-width pulses keyed to the start of the dead time period.

The wide dynamic range of the Model 1428A permits its use in many applications without the need for fast pulse amplifiers. The front panel WALK ADJUST control permits the user to trim the time walk characteristic of the experimental setup for optimum timing resolution.



Specifications

INPUTS

INPUT - accepts -5mV to -5V linear pulses; rise time 1nsec or longer; Z_{in} = 50 ohms, DC coupled; front panel BNC connector.

DELAY - 2 BNC connectors between which a delay cable is connected to form the internal constant fraction signal. Recommended lengths are based upon a cable propagation delay of $\approx$1.5nsec/ft. to provide a delay $\approx 0.2\ t_{rise}$ for Germanium detectors and $\approx 0.8\ t_{rise}$ for most other detector types.

OUTPUTS

WALK INSPECT - displays output signal of zero crossing discriminator for use in trimming time walk.

OUTPUTS (-) - 2 independent negative current outputs, each providing — 16mA into 50 ohms; rise time <3nsec; pulse width 20nsec nominal; DC coupled.

OUTPUTS (+) - 2 independent positive voltage outputs providing 2V (minimum) into 50 ohms; rise time <10nsec; width adjustable by adjacent width trimming potentiometer, which also determines internal dead time.

CLIP CABLE (rear panel) - 2 BNC connectors between which a delay cable is mated to clip the effective width of the negative output pulses; controlled by adjacent IN-OUT switch.

CONTROLS

THRESHOLD - front panel 10-turn locking dial potentiometer to set acceptance threshold for input pulses; range -5mV to -1V.

WALK ADJUST - front panel trimming potentiometer to compensate walk of the internal zero crossing discriminator.

CFSR-CF-LE - front panel three position rotary switch to select Constant Fraction with Slow Risetime reject (CFSR), basic Constant Fraction timing (CF), or Leading Edge timing (LE) modes of operation.

WIDTH - front panel 22-turn screwdriver adjust trimming potentiometer to set width of slow positive output pulse, which is equal to the internal dead time of the discriminator.

IN-OUT (rear panel) - toggle switch to permit cable clipping of width of negative outputs (IN), or normal fixed width (OUT).

PERFORMANCE

DYNAMIC RANGE - 1000:1.

WALK - in CF mode, for a 2nsec rise time pulse over a 100:1 dynamic range (reference -5), <±125psec.

COUNTING RATE - to 50MHz, limited by dead time (WIDTH setting).

PULSE PAIR RESOLUTION - <20nsec, or as limited by dead time.

Specifications(continued)

THRESHOLD STABILITY - better than ±0.02%/°C (±200ppm/°C).
TEMPERATURE RANGE - 0 to +50°C.
THRESHOLD LINEARITY - ±0.25% integral.

TYPICAL CABLE LENGTHS (RG-58)

For Plastic, NaI and Si (S.B.) Detectors - 1.5 to 3.3 ft. (0.5 to 1.0 meters).
For Planar Germanium Detectors - 3.3 to 7 ft. (1.0 to 2.0 meters).
For Coaxial Ge(Li) - 7 to 14 ft. (2.0 to 4.0 meters).

POWER REQUIREMENTS

+24VDC — 0mA		+12VDC — 120mA	
- 24VDC — 0mA		- 12VDC — 450mA*	

*This power exceeds the normal bin power allotment of 167mA for a single width NIM module.

PHYSICAL

SIZE - single width NIM module (1.35 x 8.71 inches) (3.43 x 22.13 cm) per TID-20893 (rev.).
NET WEIGHT - 2.0 lbs. (0.9 kg).
SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs).

TYPICAL RESOLUTION PERFORMANCE

Start Detector	Stop Detector	Energy	Source	FWHM	FW0.1M	FW0.01M
NE 111 RCA 8850	NE 111 RCA 8850	0.8 to 2 MeV	Co^{60}	200 psec	460 psec	720 psec
NE 111 RCA 8850	NAI(TI) RCA 8850	511 ± 5%	Na^{22}	1.2 nsec	2.8 nsec	4.4 nsec
NE 111 RCA 8850	Ge(Li) True Coax. 14% eff. 2.2keV FWHM	120keV to 1.3 MeV	Na^{22}	5.5 nsec	13.2 nsec CFRR Mode	23.0 nsec
Ge(Li) True Coax. 10% eff. 2.3keV FWHM	Ge(Li) True Coax. 10% eff. 2.3keV	>80keV	Na^{22}	11.2 nsec	22.2 nsec CFRR Mode	34.8 nsec
NE 111 RCA 8850	Ge(Li) True Coax. 14% eff. 2.2keV FWHM	>50keV	Na^{22} + Co^{57}	7.1 nsec CF Mode		

Model 1446
Universal Coincidence

Features

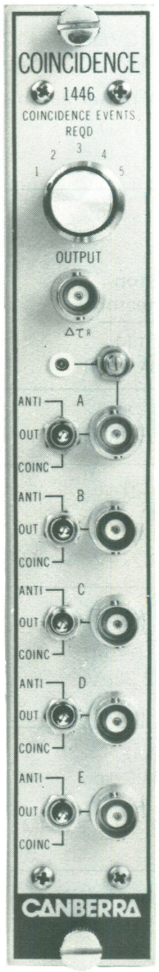
- Five DC-coupled inputs
- Three selectable modes for each input
- Resolving time variable from 100nsec to 2μsec
- Selectable number of required inputs

Description

The Canberra Model 1446 Universal Coincidence is a single-width module having five DC coupled inputs. Associated with each input is a three-position toggle switch to select coincidence (COINC), anticoincidence (ANTI), or out (OUT) mode. Coincidence analysis is of the overlap type, in which an output is generated when the inputs overlap in time.

The resolving time of input A is variable from 100 nanoseconds to 2 microseconds via a single-turn screwdriver-adjustable potentiometer. A test jack is provided to permit observation of the adjustment of the pulse at input A. Resolving times of the remaining four inputs are determined by their pulse widths.

An output pulse is obtained whenever the number of coincident pulses meets or exceeds the number selected by the COINCIDENCE EVENTS REQD rotary switch. For example, if this switch is set at "3" position, and all five inputs are being utilized in the COINC mode, the output will fire whenever a coincidence occurs between any three of the inputs. If any one or more inputs are selected for anticoincidence, the output will be inhibited while such signals are present. Two output pulses are provided — one on the front panel, and one on the rear panel. Output width and amplitude are standardized, regardless of the input widths or amount of overlap.



Specifications

INPUTS

SIGNAL INPUTS - five front panel BNC connectors accept +4 to +10 pulses, minimum width 50 nanoseconds; input impedance 1000 ohms; DC coupled.

OUTPUTS

OUTPUT - two BNC connectors (one located on the front panel, and one located on the rear panel) provide a +10 volt pulse having a width of 1 to 5 microseconds (variable via an internal potentiometer); output impedance 10 ohms; DC coupled.

CONTROLS

INPUT CONTROLS - five three-position toggle switches (one for each input) to select COINCidence, ANTIcoincidence or OUT mode; selection of OUT mode disables the respective input.

$\Delta\tau_R$ (RESOLVING TIME, INPUT A) - a single-turn screwdriver-adjustable potentiometer to adjust the resolving time of the signal at Input A over a range of 100 nanoseconds to 2 microseconds.

COINCIDENCE EVENTS REQD - front panel rotary switch to select the number of coincident events which must occur before an output pulse will be obtained.

PERFORMANCE

OPERATING TEMPERATURE - 0 to 50^{o}C.

CONNECTORS

SIGNAL INPUTS - five front panel BNC.

OUTPUT - one front and one rear panel BNC.

POWER REQUIREMENTS

+24VDC	— 0mA	+12VDC	— 130mA
-24VDC	— 0mA	-12VDC	— 70mA

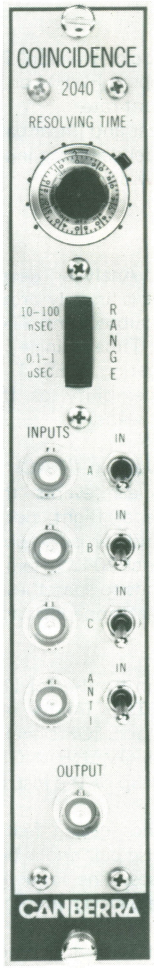
PHYSICAL

SIZE - standard single-width NIM module (1.35 x 8.71 inches) (3.43 cm x 22.13 cm) per TID-20893 (rev.).

NET WEIGHT - 2 lbs. (0.9 kgs).

SHIPPING WEIGHT - 5 lbs. (2.3 kgs).

Model 2040
Coincidence Analyzer



Features

- Range from 10 nanoseconds to 1 microsecond
- Three coincidence inputs
- Anti-coincidence input

Description

The Canberra Model 2040 Coincidence Analyzer accepts the outputs from energy analysis and time discrimination modules, such as the Canberra Model 2035A, 2036A, or 2037A Timing SCAs. The Model 2040 produces an output when all of the coincidence inputs (selected by the front panel toggle switches) occur within the resolving time selected by the front panel controls.

The long-term stability of the selected resolving time is better than 5% of setting or 3 nanoseconds, whichever is larger.

Specifications

INPUTS

COINCIDENCE AND ANTI-COINCIDENCE - accept positive 4 - 10 volt pulses; rise time less than 50 nanoseconds; duration greater than 100 nanoseconds; input impedance 2.2K ohms shunted by 120pf.

OUTPUT

OUTPUT - positive 10 volt pulse; rise time less than 50 nanoseconds; duration one microsecond; output impedance 50 ohms, DC coupled.

PERFORMANCE

COINCIDENCE RESOLVING TIME RANGES - 10 to 100 nanoseconds, or 0.1 to 1.0 microsecond

STABILITY OF RESOLVING TIME - better than 5% of setting or 3 nanoseconds, whichever is larger.

CONTROLS

RESOLVING TIME RANGE - 10 to 100 nanoseconds or 0.1 to 1.0 microsecond, front panel switch selected.

RESOLVING TIME - 1 to 10 within range select above, front panel ten-turn potentiometer control.

CHANNEL SELECTION - enable or disable each channel from coincidence evaluation, front panel switch selections (input must be present within resolving time selected for each channel enabled by these switches for an output to be generated).

CONNECTORS

All signal connectors are front panel mounted BNC type.

POWER

+24V	—	35mA	+12V	—	170mA
- 24V	—	80mA	- 12V	—	12mA

PHYSICAL

SIZE - standard single-width module (1.35 inches wide) (3.43 cm wide) per TID-20893.

NET WEIGHT - approx. 2.0 lbs. (0.9 kgs)

SHIPPING WEIGHT - approx. 4.0 lbs. (1.8 kgs).

Model 2043 Time Analyzer

Features

- 15 ranges of time-to-amplitude conversion, 20nsec to 1msec
- Time resolution $<$0.01% + 5psec FWHM on any range
- DC coupled for optimum count rate
- Built-in single channel analyzer and linear gate
- COINCidence/ANTICOINCidence gating inputs
- Selectable output delay and width

Description

The Canberra Model 2043 Time Analyzer generates a rectangular output pulse whose peak amplitude is linearly proportional to the time interval between a START and a subsequent STOP input. There are *built-in* features such as the Time Single Channel Analyzer, COINCidence/ANTICOINCidence gating, RESET, and STOP INHIBIT which enhance the utility and flexibility of this module for the spectrum of nuclear timing analysis needs.

The basic time-to-amplitude conversion (TAC) is used to analyze correlations between random nuclear events that occur within a selected interval of time, for time of flight, positron lifetime, pulse shape analysis in particle studies, and for pulse pair timing in position sensitive detector systems. The Model 2043 offers 15 time ranges from 20 nanoseconds to 1000 microseconds to span these needs. The positive unipolar TAC output is essentially flattopped for accurate measurement by a multichannel analyzer ADC.

Internal gating prevents a TAC output pulse for (1) overrange START to STOP time differences; (2) STOP inputs received prior to an accepted START; and (3) START or STOP signals received during the converter busy time. The tront panel OVERRANGE LED is illuminated for the first condition to simplify setup of the instrument.

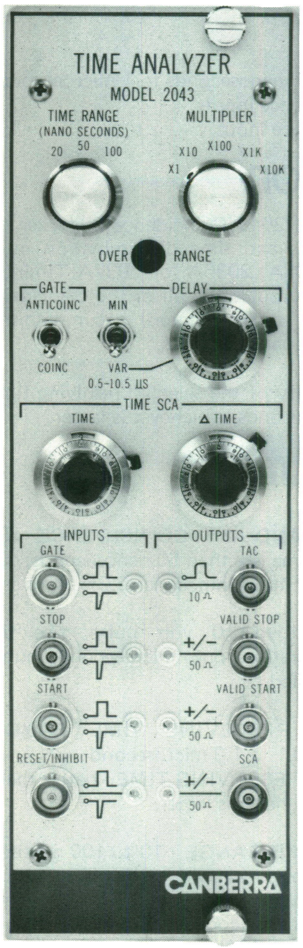
The COINCidence/ANTICOINCidence gating feature permits prompt (early) gating of a START/STOP pulse pair and is best used to minimize conversion time on unwanted pulses. The input must be received at least 10nsec prior to and overlap the START input.

The RESET/INHIBIT input permits late anticoincidence gating. It is used to terminate a conversion cycle and prevent subsequent conversions while driven. This mode prevents a TAC output for slow energy analysis restrictions, for example.

For user convenience, the START, STOP, GATE and RESET/INHIBIT inputs accept positive or negative NIM pulses without the need for polarity selection switches. The circuit provides an input impedance of 1K ohm or 50 ohms (internally selectable) for positive signals, and 50 ohms nominal to negative NIM current pulses.

The rear panel STOP INHIBIT adjustment allows rejection of STOP input signals in a range of 1% to 100% of each time range. This is useful in suppressing noise inputs in some applications such as linear accelerators, and prevents false outputs. A MONITOR output is provided for the user to observe the time between START and accepted STOP signals as a logic pulse width.

The single channel analyzer (SCA) portion of the Model 2043 operates on the TAC output pulse amplitude, and places equivalent timing restrictions on the time spectrum being accumulated. The "time window" of interest is adjustable from 0 to 100% of the selected time range by the settings of the front panel ten-turn locking dial potentiometers. An SCA logic output is produced for every TAC pulse whose peak amplitude is greater than the TIME dial setting, but less than the sum of TIME + ΔTIME settings. An internal jumper plug permits the user to gate the TAC output with the SCA directly, or to let the output be generated normally.



Both the TAC and SCA outputs are simultaneously adjustable in width (internal jumper plug for 0.5, 1.0, or 2.5µsec) and the 2 outputs are synchronous, so timing jitter on the SCA output is essentially non-existent.

VALID START and VALID STOP auxiliary logic outputs are also provided. The VALID START output duration is the time interval between an accepted START input, and the end of TAC reset time, and thus represents the full conversion busy time. The VALID STOP output duration is the time interval between an accepted STOP input, and the end of TAC reset time. Converter reset occurs after generation of a TAC output, upon receipt of a RESET/INHIBIT input, or detection of an overrange condition (no STOP input received within the selected time range). Reset time is a fixed 1µsec on the X1, X10 and X100 MULTIPLIER ranges and 10µsec maximum on the X1K and X10K ranges.

The VALID START, VALID STOP, SCA and MONITOR outputs are each available by internal selection as positive voltage pulses or negative fast NIM current pulses. The voltage outputs are also adjustable in peak amplitude for compatibility with interfacing instruments. Each positive output is source matched with a 50 ohm series resistive termination to prevent ringing due to reflections on unterminated cables, and the resulting multiple counting frequently experienced. The instrument is shipped with socketed resistors for each output which limit them to +5V nominal (open circuit) for direct interface to common TTL circuitry. The user may remove the resistors as desired to obtain a +8V

Description (continued)

nominal open circuit voltage for instruments requiring the NIM pulse level, or +4V nominal into the 50 ohm load termination which some other instruments provide. This flexibility allows the user to adapt the output signal to his needs without risking the problems encountered with improperly driven cables and critical timing pulses.

The TAC output signal is provided on the rear panel as a source matched 93 ohm output, and on the front panel as a 10 ohm output for use with short lengths of cable (less than 1 meter) interfacing to an MCA. Both are direct coupled and essentially pedestal-free.

The START, STOP, and GATE inputs are accommodated on both front and rear panels. To prevent unterminated stub pulse reflections on these NIM fast low level inputs, the user selects the front or rear inputs via internal jumper plugs. The balanced 50 ohm termination is thus preserved on the desired line for maximum noise immunity and timing stability.

Specifications

INPUTS

START - accepts either a positive logic signal or DC level with amplitude $\geqslant$2V, or a negative logic signal or DC level with amplitude $\geqslant$-250mV; width $\geqslant$2nsec at above limits; $Z_{in} \approx$1K ohm for positive signals (internally selectable by jumper plug to 50 ohms), and 50 ohms for negative signals, DC coupled; leading edge initiates time conversion cycle; front and rear panel BNC connectors.

STOP - input specifications identical to START input; leading edge terminates time conversion cycle; see INTERNAL GATING LOGIC for restrictions; front and rear panel BNC connectors.

GATE - accepts either a positive logic signal or DC level with amplitude $\geqslant$3V, or a negative logic signal or DC level with amplitude $\geqslant$-500mV; width $\geqslant$50nsec; $Z_{in} \approx$1K ohm for positive signals (selectable internally to 50 ohms), and 50 ohms for negative signals, DC coupled; provides external means of gating the TAC output in either COINCidence or ANTIcoincidence. GATE input must begin 10nsec prior to and overlap START input signal; front and rear panel BNC connectors.

RESET/INHIB - input specifications identical to GATE input; serves as a late anticoincidence input and terminates conversion cycle; front panel BNC connector.

OUTPUTS

TAC - provides positive flattopped rectangular unipolar pulse; constant pulse shape independent of TIME RANGE or amplitude; amplitude proportional to accepted START/STOP input pulse time difference; adjustable delay (0.5 to 10.5μsec) and width (0.5, 1.0 or 2.5μsec); rise time $\approx$250nsec; DC coupled; front (Z_{out} <10 ohms) and rear panel (Z_{out} = 93 ohms) BNC connectors.

VALID START (converter busy time) - provides internally selectable positive voltage pulse of 5 or 8V, with rise and fall times of <25nsec, or by another internal selection a negative current pulse of -16mA with rise time of <5nsec; Z_{out} = 50 ohms, DC coupled; duration equal to time interval between accepted START input and end of cycle reset time; front panel BNC connector.

VALID STOP - output pulse specifications identical to VALID START; duration equal to time interval between accepted STOP input signal and end of cycle reset time; front panel BNC connector.

SCA - output pulse specifications identical to VALID START; leading edge in time coincidence with, and duration equal to, TAC output; front panel BNC connector.

STOP INHIBIT MONITOR - output pulse specifications identical to VALID START; provides observation of rear panel STOP INHIBIT RANGE adjustment; rear panel BNC connector.

FRONT PANEL CONTROLS

TIME RANGE - three-position rotary switch to select full scale time interval of 20, 50, or 100nsec between accepted START and STOP input pulses.

MULTIPLIER - five position rotary switch to extend TIME RANGE by X1, X10, X100, X1K or X10K.

DELAY - 10-turn locking dial potentiometer to vary TAC output delay time; 0.5 to 10.5μsec range, with adjacent toggle switch in VARiable; fixed 150nsec relative to STOP input with switch in MINimum.

GATE MODE - toggle switch to select COINCidence or ANTICOINCidence gated mode of operation. Time conversion is enabled (COINC) or inhibited (ANTICOINC) upon receipt of a GATE input signal.

TIME - 10-turn locking dial potentiometer to select minimum time of interest from 0 to 100% of selected TIME RANGE.

ΔTIME - 10-turn locking dial potentiometer to select time window width from 0 to 100% of selected TIME RANGE.

REAR PANEL CONTROLS

STOP INHIBIT - toggle switch to enable (IN) or disable (OUT) STOP INHIBIT RANGE adjustment.

STOP INHIBIT RANGE single-turn potentiometer to reject unwanted STOP input signals from a minimum of 1% up to 100% of selected TIME RANGE (minimum 20nsec). Set for front panel when shipped.

INTERNAL CONTROLS

SCA IN/SCA OUT - jumper plug to enable the SCA logic to gate TAC output (IN), or allow normal TAC output (OUT).

OUTPUT WIDTH - jumper plug to select 0.5, 1.0 or 2.5μsec output pulse width for both SCA and TAC outputs.

START SELECT, STOP SELECT, GATE SELECT - jumper plugs to select either front or rear panel BNC connectors for input START, STOP or GATE signals. Set for front panel when shipped.

VALID START +/–, VALID STOP +/–, SCA +/–, STOP INHIBIT +/– - jumper plugs to select either positive voltage or negative current mode outputs for the related BNC connectors.

PERFORMANCE

TIME RESOLUTION - <0.01% of full scale plus 5psec FWHM for all ranges.

TAC INTEGRAL NONLINEARITY - <±0.1% from 5nsec to full scale on X1 MULTIPLIER range; <±0.1% from 1% to 100% of full range for all higher ranges.

TAC DIFFERENTIAL NONLINEARITY - <±2% from 5nsec to full scale on X1 MULTIPLIER range; <±2% from 1% to 100% of full range for al! higher ranges.

SCA TIME/ΔTIME INTEGRAL NONLINEARITY - <±0.5% of full scale.

TAC OUTPUT TEMPERATURE STABILITY - better than ±0.01%/°C (±100ppm/°C) of full scale.

SCA TIME/ΔTIME TEMPERATURE STABILITY - better than ±0.01%/°C (±100ppm/°C) of full scale.

OUTPUT DELAY/OUTPUT WIDTH TEMPERATURE STABILITY - better than 0.01%/°C (±100ppm/°C) of full scale.

TEMPERATURE OPERATING RANGE - 0 to 50°C.

TAC OUTPUT DROOP - <0.015%/μsec of output delay on all ranges.

TAC RESET TIME - fixed 1μsec recovery time on X1, X10 and X100 MULTIPLIER ranges, and 10μsec on X1K and X10K MULTIPLIER ranges; occurs after each normal output and each overrange.

GATE PEDESTAL - essentially zero pedestal, factory calibrated.

SCA OUTPUT TIME WALK - none, with respect to TAC output.

MINIMUM START TO STOP CONVERSION TIME - $\approx$2nsec.

COUNT RATE CAPABILITY - all inputs and outputs are DC coupled for optimum count rate independence; maximum internal count rate is limited by the converter busy time (time interval between accepted START input and end of reset time).

INTERNAL GATING LOGIC - prevents TAC output for (1) overrange STOP signals; (2) STOP signals prior to an accepted START, (3) START/STOP inputs during converter busy time (eliminates pulse pileup).

CONNECTORS

All signal connectors are BNC type.

POWER REQUIREMENTS

+24VDC	—	30mA	+12VDC	—	250mA
-24VDC	—	50mA	-12VDC	—	100mA

PHYSICAL

SIZE - standard double-width NIM module (2.70 x 8.71 inches) (6.85 x 22.13 cm) per TID-20893 (rev).

NET WEIGHT - 2.8 lbs. (1.3 kgs).

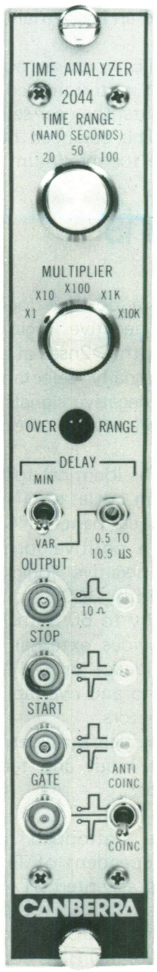
SHIPPING WEIGHT - 5.0 lbs. (2.3 kgs).

Model 2044 Time Analyzer

Features

- 15 ranges of time-to-amplitude conversion, 20nsec to 1msec
- Time resolution <0.01% + 5psec FWHM on any range
- DC coupled for optimum count rate
- COINCidence/ANTICOINCidence gating inputs
- Selectable output delay and width

Description



The Canberra Model 2044 Time Analyzer generates a rectangular output pulse whose peak amplitude is linearly proportional to the time interval between a START and a subsequent STOP input. The built-in COINCidence/ANTICOINCidence gating, and OVERRANGE indicator enhance the utility and flexibility of this module for the majority of nuclear timing analysis needs.

The basic time-to-amplitude conversion is used to analyze correlations between random nuclear events that occur within a selected interval of time, for time of flight, positron lifetime, pulse shape analysis in particle studies, and for pulse pair timing in position sensitive detector systems. The Model 2044 offers 15 time ranges from 20 nanoseconds to 1000 microseconds to span these needs. The positive unipolar OUTPUT is essentially flat topped for accurate measurement by a multichannel analyzer ADC.

Internal gating prevents an OUTPUT pulse for (1) overrange START to STOP time differences; (2) STOP inputs received prior to an accepted START; and, (3) START or STOP signals received during the converter busy time. The front panel OVERRANGE LED is illuminated for the first condition to simplify setup of the instrument.

The COINCidence/ANTICOINCidence gating feature permits prompt (early) gating of a START/STOP pulse pair and is best used to minimize conversion time on unwanted pulses. The GATE input must be received at least 10nsec prior to and overlap the START input.

For user convenience the START, STOP and GATE inputs accept positive or negative NIM pulses without the need for a polarity selection switch. The circuit provides an input impedance of 1K ohm or 50 ohms (internally selectable) for positive signals, and 50 ohms nominal to negative NIM current pulses.

The OUTPUT pulse may be delivered immediately upon completion of the START to STOP conversion by using the MINimum DELAY switch on the front panel, or may be delayed over a range of 0.5 to 10.5µsec using a 22-turn screwdriver adjustment potentiometer. The OUTPUT pulse width is set by an internal jumper plug for 0.5, 1.0 or 2.5µsec.

Converter reset occurs after generation of an OUTPUT, or detection of an overrange condition (no STOP input received within the selected TIME RANGE). Reset time is a fixed 1µsec on the X1, X10 and X100 MULTIPLIER ranges and 10µsec maximum on the X1K and X10K ranges.

The OUTPUT signal is provided on the rear panel as a source matched 93 ohm output, and on the front panel as a 10 ohm output for use with short lengths of cable (less than 1 meter) interfacing to an MCA. Both are direct coupled and essentially pedestal-free.

The START, STOP, and GATE inputs are accommodated on both front and rear panels. To prevent unterminated stub pulse reflections on these NIM fast low level inputs, the user selects the front or rear inputs via internal jumper plugs. The balanced 50 ohm termination is thus preserved on the desired line for maximum noise immunity and timing stability.

Careful attention has been paid to minimize crosstalk of the fast logic pulses. The OUTPUT and the START and STOP inputs employ isolated BNCs to prevent circulating pulse currents in the instrument Bin.

Specifications

INPUTS

START - accepts either a positive logic signal or DC level with amplitude ⩾2V, or a negative logic signal or DC level with amplitude ⩾-250mV; width ⩾2nsec at above limits; Z_{in} ≈1K ohm for positive signals (internally selectable by jumper plug to 50 ohms), and 50 ohms for negative signals, DC coupled; leading edge initiates time conversion cycle; front and rear panel BNC connectors.

STOP - input specifications identical to START input; leading edge terminates time conversion cycle; see INTERNAL GATING LOGIC for restrictions; front and rear panel BNC connectors.

GATE - accepts either a positive logic signal or DC level with amplitude ⩾3V, or a negative logic signal or DC level with amplitude ⩾-500mV; width ⩾50nsec; Z_{in} ≈1K ohm for positive signals (internally selectable by jumper plug to 50 ohms), and 50 ohms for negative signals, DC coupled; provides external means of gating the TAC OUTPUT in either COINCidence or ANTIcoincidence. GATE input must begin 10nsec prior to, and overlap START input signal; front and rear panel BNC connectors.

OUTPUT

OUTPUT - provides positive flattopped rectangular unipolar pulse; constant pulse shape independent of TIME RANGE or amplitude; amplitude proportional to accepted START/STOP input pulse time difference; adjustable delay (0.5 to 10.5µsec) and width (0.5, 1.0 or 2.5µsec); rise time ≈250nsec; DC coupled; front (Z_{out} <10 ohms) and rear panel (Z_{out} = 93 ohms) BNC connectors.

FRONT PANEL CONTROLS

TIME RANGE - three-position rotary switch to select full scale time interval of 20, 50, or 100nsec between accepted START and STOP input pulses.

MULTIPLIER - five position rotary switch to extend TIME RANGE by X1, X10, X100, X1K or X10K.

DELAY - 22-turn screwdriver adjustment potentiometer to vary OUTPUT delay time; 0.5 to 10.5µsec range.

MIN/VAR - toggle switch to select delay of OUTPUT following completion of START/STOP conversion cycle, MINimum delay 150nsec. VARiable delay per screwdriver adjustment.

GATE MODE - toggle switch to select COINCidence or ANTICOINCidence gated mode of operation; time conversion is enabled (COINC) or inhibited (ANTICOINC) upon receipt of a GATE input signal.

INTERNAL CONTROLS

OUTPUT WIDTH - jumper plug to select 0.5, 1.0, or 2.5µsec pulse width for OUTPUT.

START SELECT, STOP SELECT, GATE SELECT - jumper plugs to select either front or rear panel BNC connectors for input START, STOP or GATE signals. Set for front panel when shipped.

PERFORMANCE

TIME RESOLUTION - <0.01% of full scale +5psec FWHM on all ranges.

INTEGRAL NONLINEARITY - <±0.1% from 5nsec to full scale on X1 MULTIPLIER range; <±0.1% from 1% to 100% of full range for all higher ranges.

DIFFERENTIAL NONLINEARITY - <±2% from 5nsec to full scale on X1 MULTIPLIER range; <±2% from 1% to 100% of full range for all higher ranges.

OUTPUT TEMPERATURE STABILITY - better than ±0.01%/°C.

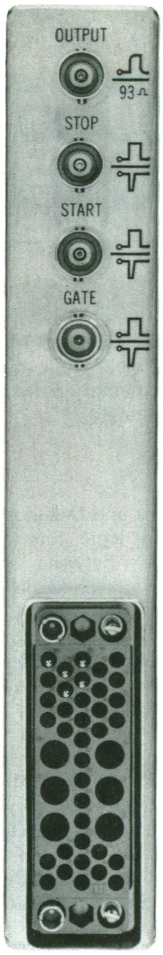
OUTPUT DELAY/OUTPUT WIDTH TEMPERATURE STABILITY - better than ±0.01%/°C (±100ppm/°C) of full scale.

TEMPERATURE OPERATING RANGE - 0 to 50°C.

OUTPUT DROOP - <0.015%/µsec of output delay on all ranges.

RESET TIME - fixed 1µsec recovery time on X1, X10 and X100 MULTIPLIER ranges, and 10µsec on X1K and X10K MULTIPLIER ranges; occurs after each normal output and each overrange.

GATE PEDESTAL - essentially zero pedestal, factory calibrated.



MINIMUM START TO STOP CONVERSION TIME - ≈2nsec, equal to circuit propagation delays.

COUNT RATE CAPABILITY - all inputs and outputs are DC coupled for optimum count rate independence; maximum internal count rate is limited by the converter busy time (time interval between accepted START input and end of reset time).

INTERNAL GATING LOGIC - prevents OUTPUT for (1) overrange STOP signals; (2) STOP signals prior to an accepted START; (3) START/STOP inputs during converter busy time (eliminates pulse pileup).

CONNECTORS

All signal connectors are BNC type.

POWER REQUIREMENTS

+24VDC	—	30mA	+12VDC	—	160mA
-24VDC	—	30mA	-12VDC	—	60mA

PHYSICAL

SIZE - standard single-width NIM module (1.35 x 8.71 inches) (3.42 cm x 22.13 cm) per TID-20893 (rev).

NET WEIGHT - 1.8 lbs. (0.8 kgs).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs).

Model 2055
Logic Shaper and Delay

Features

- Variable time delay from 0.1 to 110μs
- Simultaneous fast/slow NIM logic outputs
- Simultaneous complementary period outputs
- Excellent time delay stability

Description

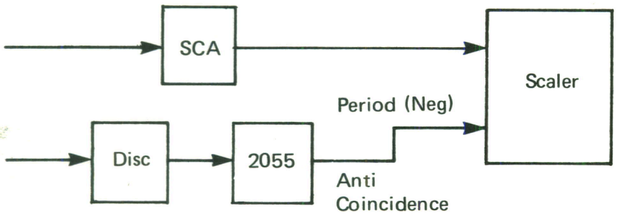
The Model 2055 Logic Shaper and Delay offers 5 versatile logic outputs to solve many timing and logic interface problems. In addition input/output incompatibility between instruments from different manufacturers is eliminated with the Model 2055.

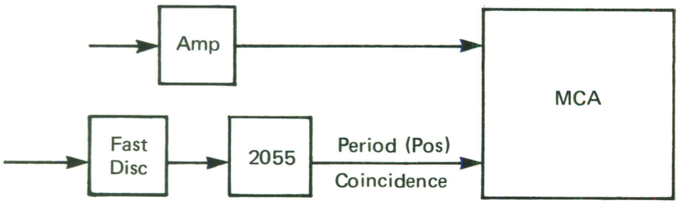
In timing applications, this instrument compensates for inter-channel timing differences in fast/slow coincidence experiments. Since the PERIOD OUTPUT is available as both normal and complementary slow NIM pulses, both coincidence and anticoincidence measurements can be performed.

The range of delay (0.1 to 110μs) allows the Model 2055 to be used in a wide variety of timing experiments from fast NIM logic applications to slow gas proportional detector anticoincidence measurements.

Input pulses of either polarity generate the five simultaneous outputs for the experimenter's use. Separate POSitive and NEGative OUTPUT logic signals are available with continuously adjustable delay, width, and amplitude. Accompanying OUTPUTS include a FAST negative NIM logic output following the selected delay time and a PERIOD OUTPUT with its width equal to the delay time. Thus, logic signals meeting the input requirements of the Model 2055 may be reshaped and delayed up to 110 microseconds to provide maximum logic interface capability.

Typical interfacing applications are illustrated below:

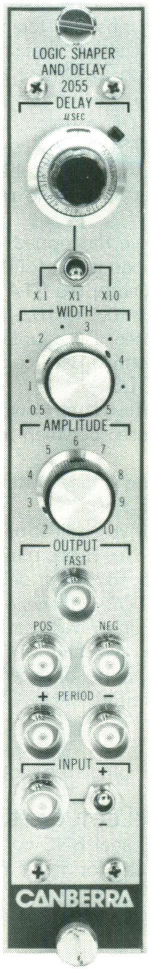




Specifications

INPUTS

INPUT - accepts positive 0.7 to 12V or negative - 0.4 to - 12V logic pulses, any rise time, minimum width 20 nanoseconds at ±1V: Z_{in} ≈1K ohms, DC coupled, front and rear panel BNC connectors.



OUTPUTS

POSitive - variable amplitude range +2 to +10V; variable width range 0.5 to 5μsec; variable delay range 0.1 to 110μsec (plus propagation delay of approximately 75 nanoseconds) rise and fall times ≤25 nanoseconds; Z_{out} ≤25 ohms; short circuit protected, DC coupled, front panel BNC connector.

NEGative - variable amplitude, range, - 2 to - 10V; other characteristics identical to POSitive OUTPUT.

FAST - standard fast negative NIM logic pulse; - 800mV into 50 ohms load; rise time ≤5 nanoseconds, width ≈20 nanoseconds; Z_{out} ≤50 ohms; short-circuit protected, DC coupled, front panel BNC connector.

+ PERIOD - logic pulse; amplitude +5V nominal; width equal to selected DELAY; rise and fall times ≤25 nanoseconds; Z_{out} ≤25 ohms; short circuit protected, DC coupled, front panel BNC connector.

- PERIOD - logic pulse; amplitude 0 to 0.5V from nominal +5 volt level; width equal to selected DELAY; rise and fall times ≤25 nanoseconds, Z_{out} ≤25 ohms; short circuit protected, DC coupled, front and rear panel BNC connectors.

Specifications(continued)

CONTROLS

DELAY - front panel ten-turn locking dial precision potentiometer, continuously variable from 100 nanoseconds to 110μsec (plus propagation delay ≈75 nanoseconds) in three overlapping ranges.

MULTIPLIER - front panel toggle switch to select DELAY potentiometer range of 0.1 to 1.1μsec, 1.0 to 11μsec, or 10 to 110μsec via X0.1, X1, or X10 positions respectively.

WIDTH - front panel single-turn potentiometer to simultaneously adjust the POSitive and NEGative OUTPUT widths; 0.5 to 5μsec range.

AMPLITUDE - front panel single-turn potentiometer to simultaneously adjust the POSitive and NEGative OUTPUT amplitudes; 2 to 10V range.

INPUT +/– - front panel toggle switch selects either positive or negative position to match logic input pulse polarity.

PERFORMANCE

DELAY NONLINEARITY - less than ±0.5% of selected DELAY range, limited by potentiometer characteristic.

DELAY STABILITY - better than ±0.1%/°C of DELAY selected.

DELAY JITTER - less than 0.02% of selected DELAY range.

PULSE PAIR RESOLUTION - selected delay + 200 nanoseconds. If POS or NEG OUTPUT is used, pulse pair resolution = selected delay + selected width + 200 nanoseconds.

CONNECTORS

INPUT, POS, NEG, FAST, + PERIOD, - PERIOD - front panel BNC.

INPUT, - PERIOD - rear panel BNC.

POWER

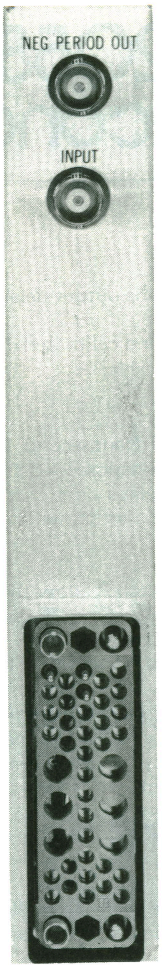
+24V	—	0mA	+12V	—	110mA
-24V	—	0mA	-12V	—	70mA

PHYSICAL

SIZE - standard single-width NIM module (1.35 x 8.71 inches) (3.43 x 22.13 cm) per TID-20893 (rev.)

NET WEIGHT - 1.6 lbs. (0.7 kgs.)

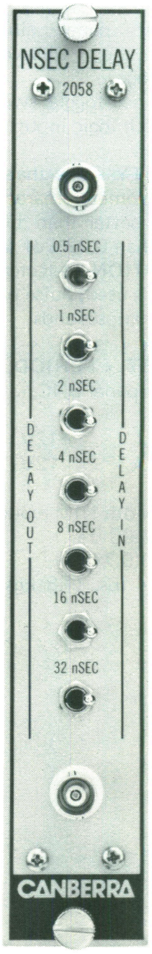
SHIPPING WEIGHT - 4 lbs. (1.8 kgs.)



Model 2058
Nanosecond Delay

Features

- Up to 63.5 nanoseconds output delay selected in 0.5 nanosecond increments
- Typical ±20 picosecond calibrated delay accuracy



Description

The Canberra Model 2058 Nanosecond Delay permits the delay of linear or logic signals in 0.5 nanosecond steps, in a range of up to 63.5 nanoseconds. As the delays are accomplished by means of interconnected coaxial cables, no power is required for operation of the module.

Seven front panel toggle switches allow the selection of 0.5, 1, 2, 4, 8 16 or 32 nanoseconds of delay time. These delays may be added in any combination. Delay times greater than 63.5 nanoseconds may be obtained by cascading several Nanosecond Delay units.

The Model 2058 is useful in the alignment of fast timing channels which operate coincidence circuits or time to pulse height converters. The high degree of accuracy in delay time selection is an aid to the calibration of such equipment.

Specifications

INPUTS

INPUT - accepts positive or negative Slow/Fast NIM logic or linear pulses, ±600 volts maximum; impedance 50 ohms; isolated front panel BNC connector

OUTPUTS

OUTPUT - provides delayed pulse, amount of delay being equal to sum of IN switches; impedance 50 ohms; isolated front panel BNC connector

CONTROLS

DELAY - seven front panel toggle switches to select delay of 0.5, 1, 2, 4, 8, 16 or 32 nanoseconds; may be added in any combination; maximum delay of 63.5 nanoseconds

PERFORMANCE

DELAY RANGE - switch selectable 0.5 to 63.5 nanoseconds in 0.5 nanosecond increments beyond minimum delay

MINIMUM DELAY - 2.0 nanoseconds (all switches in OUT position)

DELAY ACCURACY - typical ±20 picoseconds for each IN delay switch, ±100 picoseconds maximum

TEMPERATURE OPERATING RANGE - 0 - 50°C

CONNECTORS

SIGNAL INPUT, SIGNAL OUTPUT - front panel, BNC

POWER

No power required for operation

PHYSICAL

SIZE - standard single-width NIM module (1.35 x 8.71 inches) (3.5 cm x 22.1 cm) per TID-20893 (rev.)

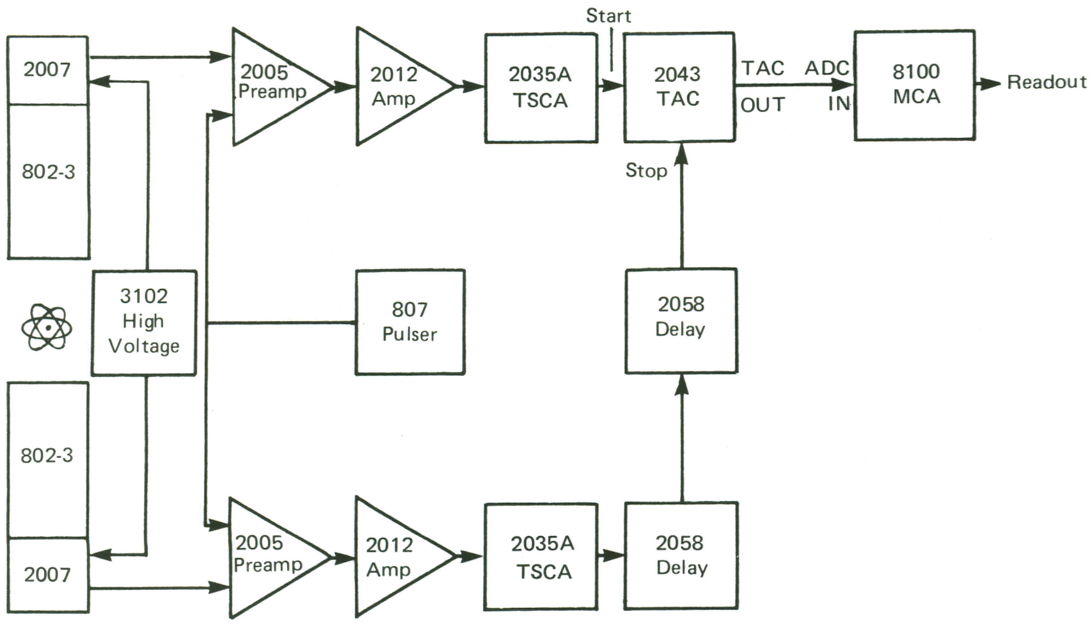
NET WEIGHT - 1.7 lbs. (0.8 kg)

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs).

TYPICAL APPLICATION

COINCIDENCE COUNTING TECHNIQUE

Many nuclear processes, such as decay of an excited state by gamma ray emission occur in very short times, so that a sequence of events is essentially simultaneous. The determination that two nuclear events occur at the same time is made electronically with a coincidence circuit. The coincidence circuit operates on standardized pulses and determines whether they occur within a certain time interval. The figure below illustrates a typical coincidence measurement system where the Model 2058 is used to store a spectrum in the Multichannel Analyzer calibrated in nanoseconds.


2007
802-3
3102
High
Voltage
802-3
2007
2005
Preamp
2012
Amp
807
Pulser
2005
Preamp
2012
Amp
2035A
TSCA
Start
2043
TAC
Stop
2058
Delay
2035A
TSCA
2058
Delay
TAC
OUT
ADC
IN
8100
MCA
Readout

Model 2110
Timing Filter Amplifier

Features

- Fully direct coupled circuitry for high count rates
- Fast (5 nanosecond) tranconductance output
- Independent differentiation and integration
- Delay cable clipping for use with pulsed optical feedback preamplifiers, or narrow clipping at high count rates.
- Ultra low noise
- Continuously adjustable gain from X1.5 to X100

Description

The Canberra Model 2110 is a wideband DC coupled amplifier designed for maximum flexibility in the nuclear physics laboratory. The unit accepts positive or negative impulses from a wide range of detector preamplifiers and provides continuously adjustable gain, selectable differentiation and/or integration, and DC level adjustment to suit the needs of advanced experimental work. The unit delivers an output of up to ±5V into a 50 ohm load.

Primarily designed to enhance timing analyses with moderate (NaI) to slow [Ge(Li)] speed radiation detectors when used on conjunction with a constant fraction discriminator such as the Model 1428, this instrument will still fullfill the needs of more general laboratory applications requiring a stable DC coupled fast pulse amplifier.

The gain range of the Model 2110 has been keyed to the most common laboratory requirements, and spans a range of X1.5 to X100. To provide maximum resolution and user convenience, the switch selectable gain range increments in binary steps from X3 to X100, and the fine gain control range is ≈X0.4 to X1.0.

A pair of front panel connectors is available to employ delay cable clipping of the input. This feature is useful in extracting the desired signal from varying DC levels on the source signal such as the ramp of pulsed optical feedback preamplifiers when single differentiation may be undesirable because of tailing or uncompensated secondary time constants. Delay cable clipping also provides the fastest shaping possible, and is most effective in processing very high count rate inputs. The Canberra Model 2058 Delay module provides the required 50 ohm impedance cable and permits delays up to 63.5 nanoseconds in 0.5 nanosecond increments.

The front panel shaping switches permit defeat of differentiation (full DC coupling) and/or integration, or independent selection of RC clipping and/or smoothing time constants of 10, 20, 50, 100 or 200 nanoseconds as required. The user may also employ fast differentiation and integration in conjunction with a delay cable at the input as provided to generate a fast bipolar shaped timing signal for zero crossing analysis.

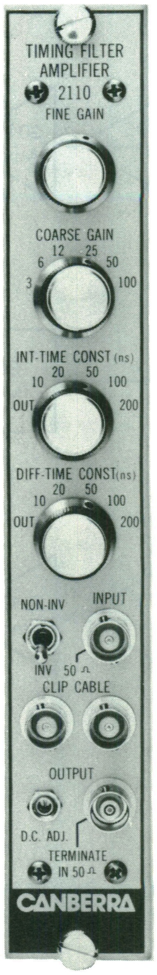
Specifications

INPUT

INPUT - accepts positive or negative detector or preamplifier impulses; when used with clipping cable, accepts DC levels of up to ±3V; input clamp protected to ±6V; input impedance 50 ohms, DC coupled.

CLIP CABLE - a pair of front panel connectors accommodates any length of 50 ohm cable to provide delay clipping of the input pulse shape and rejection of the common mode DC level.

OUTPUT - provides ±5.0V minimum to a 50 ohm load, with shaping or polarity as selected by front panel controls; short circuit proof current source output, direct coupled.



CONTROLS

FINE GAIN - front panel single-turn potentiometer to continuously vary gain over a range of ≈0.4 to 1.0 times the setting of the COARSE GAIN switch.

COARSE GAIN - 6 position front panel rotary switch to select coarse gain of X3, X6, X12, X25, X50 or X100.

DIFFerentiate TIME CONSTant - 6 position front panel rotary switch to select DC coupling in OUT, or single differentiating (clipping) RC time constants of 10, 20, 50, 100 or 200 nanoseconds.

INTegrate TIME CONSTant - 6 position front panel rotary switch to select wideband mode in OUT (rise time ⩽5 nanoseconds), or single integrating (smoothing) RC time constant of 10, 20, 50, 100, or 200 nanoseconds.

NON-INVert/INVert - front panel toggle switch to select polarity of the output signal with respect to that of the applied input.

DC ADJust - front panel screwdriver adjustment potentiometer to set the DC level of the output. Range ±0.5VDC minimum.

Specifications(continued)

PERFORMANCE

RISE TIME - with INT-TIME CONST control set to OUT, rise time is ⩽5 nanoseconds for up to ±5V output to an external 50 ohm resistive load.

OVERSHOOT - <10% for above condition, <2% for any other selected integration.

NONLINEARITY - ⩽±1% for up to ±5V output to an external 50 ohm resistive load with any selected shaping.

GAIN STABILITY - better than ±0.1%/°C, 0 to +50°C.

DC DRIFT - output DC level shift ⩽±1mV/°C, 0 to +50°C.

NOISE - for maximum gain, RMS noise referred to the input is <50µV in a wideband mode (DIFF and INT-TIME CONST switches in OUT positions) over a 100MHz bandwidth. With 200 nanosecond DIFF and INT-TIME constant selections, RMS noise referred to the input is <15µV.

CONNECTORS

All signal connectors are front panel mounted BNC types.

POWER

+24V	–	60mA	+12V	–	400mA*
- 24V	–	0	- 12V	–	360mA*

PHYSICAL

SIZE - standard single width NIM module (1.35 x 8.71 inches) (3.5 x 22.1 cm) per TID-20893 (rev.)

NET WEIGHT - 1.9 lbs. (0.9 kg).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kg).

*This power exceeds the normal bin power allotment of 167mA for a single-width module.

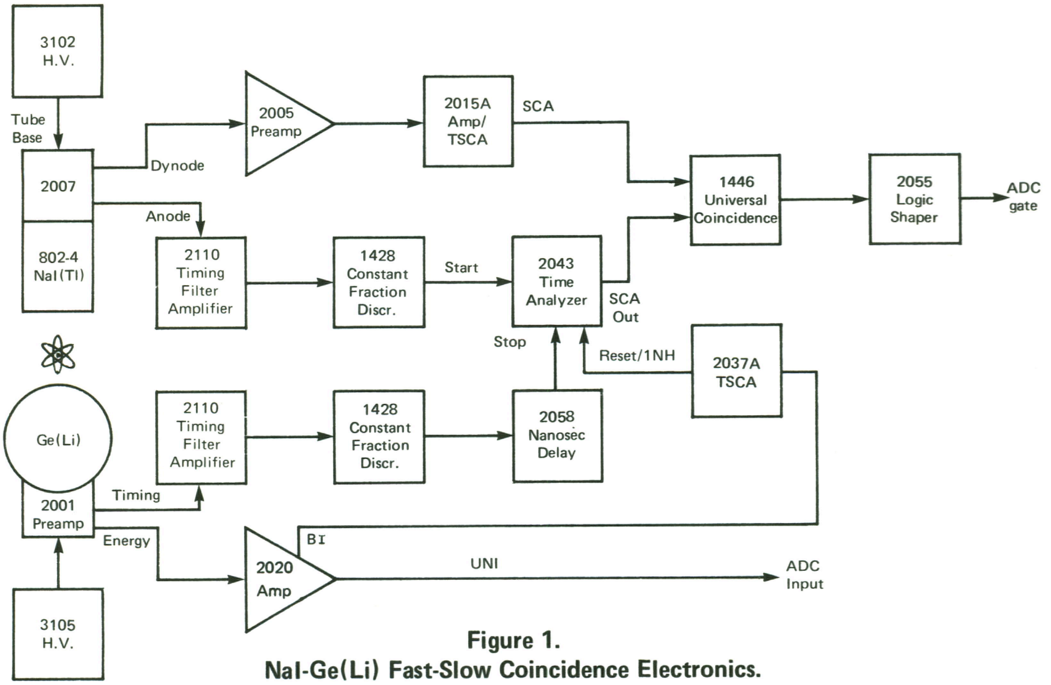

3102
H.V.
Tube Base
2007
Dynode
Anode
802-4
NaI(Tl)
2005
Preamp
2015A
Amp/
TSCA
SCA
1446
Universal
Coincidence
2055
Logic
Shaper
ADC
gate
2110
Timing
Filter
Amplifier
1428
Constant
Fraction
Discr.
Start
2043
Time
Analyzer
SCA
Out
Stop
Reset/INH
2037A
TSCA
Ge(Li)
2110
Timing
Filter
Amplifier
1428
Constant
Fraction
Discr.
2058
Nanosec
Delay
2001
Preamp
Timing
Energy
BI
2020
Amp
UNI
ADC
Input
3105
H.V.

Figure 1.
NaI-Ge(Li) Fast-Slow Coincidence Electronics.

BASIC SHAPINGS

All illustrations are at 1V/DIV. vertically, 50nsec/DIV horizontally. Input is step pulse. Output illustrated for positive only.

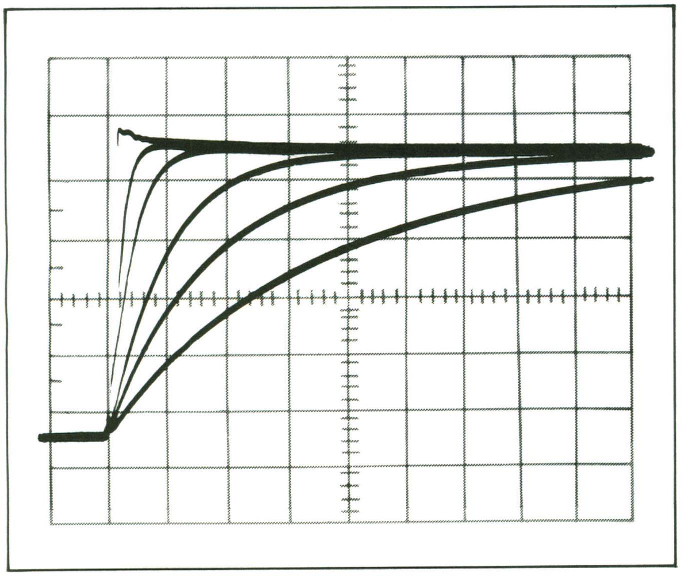


Figure 1: INTegration (with DIFFerentiation OUT) for positions OUT, 10, 20, 50, 100 and 200 nanoseconds.

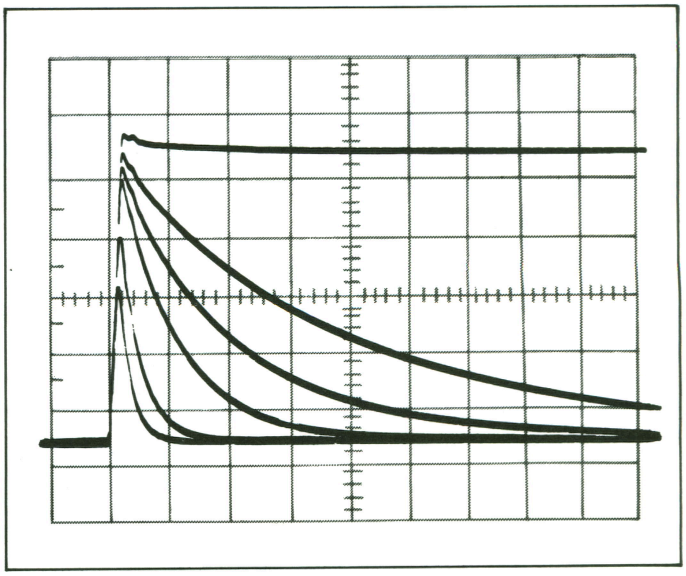


Figure 2: DIFFerentiation (with INTegration OUT) for positions OUT, 10, 20, 50, 100 and 200 nanoseconds.

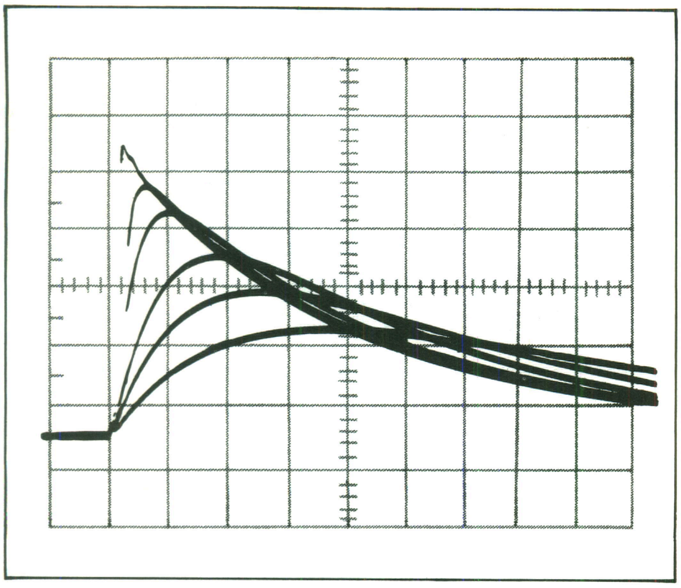


Figure 3: Effects of selected INTegrations of OUT, 10, 20, 50, 100 and 200 nanoseconds for set 200 nanosecond DIFFerentiation.

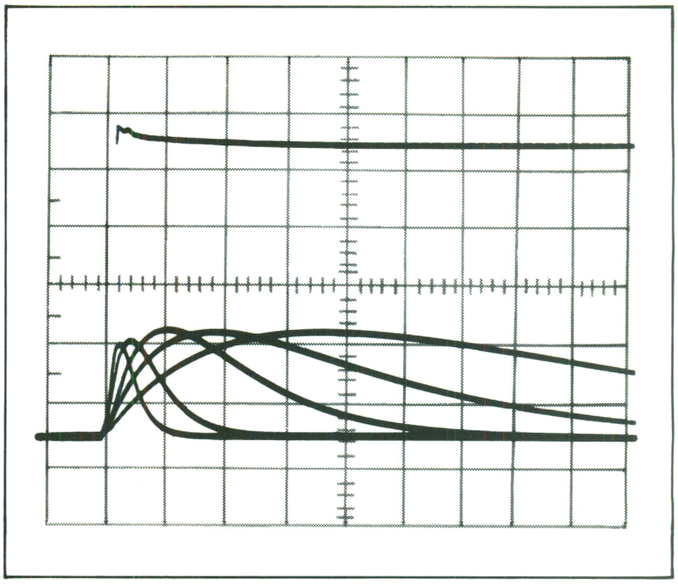


Figure 4: Waveshapes for equal INTegrations and DIFFerentiations of OUT, 10, 20, 50, 100 and 200 nanoseconds successively.

APPLICATIONS USING CLIP CABLE

Illustrations with output at 1V/DIV. vertically; horizontal at 50nsec/DIV.

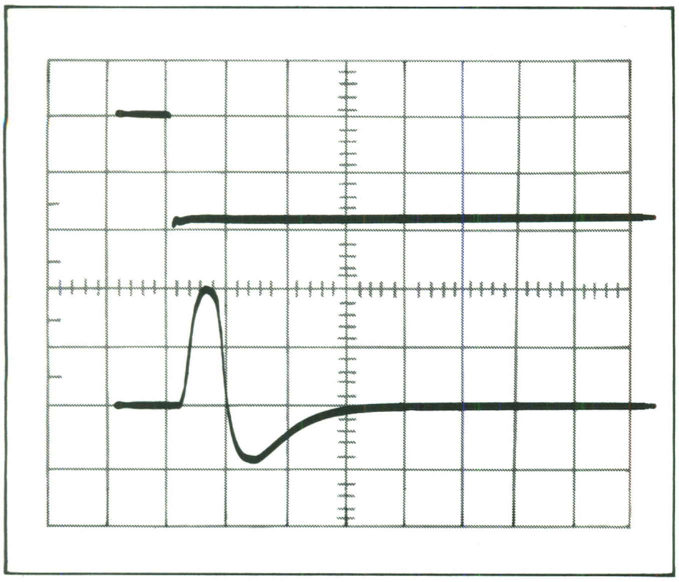


Figure 5: Bipolar output pulse for step input simulating pulse from pulsed-optical feedback preamp. Clip cable, INT and DIFF each 20 nanoseconds.

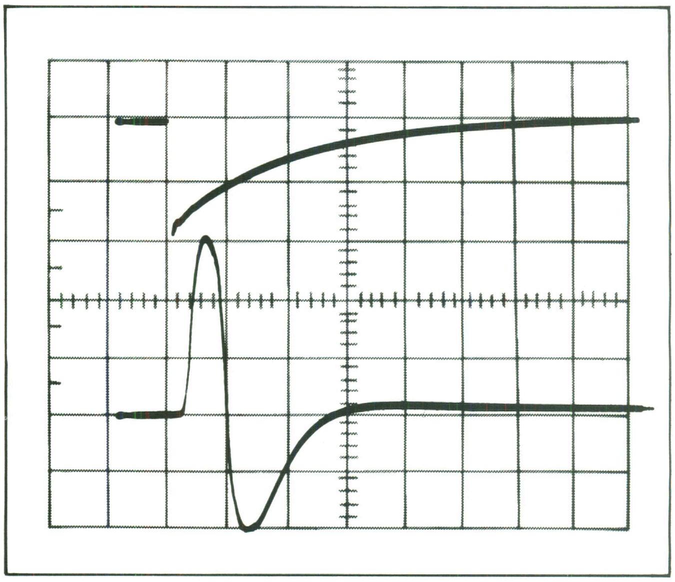


Figure 6: Bipolar output pulse for fast tail pulse input. Clip cable, INT and DIFF each 20 nanoseconds.

Model 2144A Fast/Slow Coincidence

Features

- 5 Independent input channels
- Each input accepts fast or slow NIM logic without switching
- Provides simultaneous overlap and shaped coincidence or anticoincidence outputs
- Resolving time (input overlap) <3 nanoseconds
- Pulse pair resolution <10 nanoseconds
- Selectable triggering and width of shaped positive and negative outputs

FAST/SLOW
COINCIDENCE
2144A
COINC
IN A
ANTI
COINC
IN B
IN C
IN D
IN E
OVERLAP
$\overline{\text{OVERLAP}}$
SHAPED OUTPUTS
TRIG
WIDTH
OVERLAP
1
VAR
2
CANBERRA

Description

The Model 2144A provides in a single width NIM module a high speed multiple input coincidence/anticoincidence analyzer which provides both overlap period and adjustable width coincidence logic outputs for the needs of sophisticated experiments.

Each of the 5 inputs accepts independently a fast negative NIM current pulse or a slow positive NIM voltage pulse as the logic input without the need for selector switches. Input impedance is 50 ohms for negative inputs, and 1K ohm (selectable internally to 50 ohms) for positive inputs.

Each input is enabled by its toggle switch on the front panel adjacent to the relevant connector for use in coincidence (logical AND), anticoincidence (logical OR), or OFF as desired. It is possible to use up to 4 inputs as veto (anticoincidence) for 1 in vote (coincidence).

The fast coincidence result in the Model 2144A is provided on the front panel as a negative NIM pulse, the period being equal to the duration of the selected coincidence. Both normal OVERLAP and complementary $\overline{\text{OVERLAP}}$ are available simultaneously. The user may recognize that by deMorgan's Theorem, if all inputs are selected for the anticoincidence function (logical $\overline{\text{OR}}$ = $\overline{\text{AND}}$) the logic output is provided properly on the $\overline{\text{OVERLAP}}$ output and its complement on the OVERLAP output.

The shaped outputs may be triggered by either the leading edge or the trailing edge of the overlap period by selecting the ‾⌊__⌋‾ or the ‾⌊__⌋‾ of the fast OVERLAP, respectively. The width of the shaped outputs may be adjusted between 50 nanoseconds and 10 microseconds using a screwdriver-adjust trimming potentiometer. Outputs are provided on the front panel as dual fast negative NIM pulses and dual slow positive NIM pulses. An internal jumper plug may be set to provide a complementary logic output for either or both positive and negative shaped outputs on the lowest BNC connectors.

The circuitry of the Model 2144A is entirely DC coupled, and the front end through the OVERLAP outputs is capable of resolving pulses separated by <10 nanoseconds. The shaped outputs will be limited by the selected pulse width.

Specifications

INPUTS

INPUT - IN A, IN B, IN C, IN D, IN E -5 independent front panel inputs accept either positive NIM logic levels (⩾+ 2.0V peak, width ⩾5nsec), or negative NIM logic levels (⩾-0.6V peak, width ⩾2nsec); input rise time 1nsec to 100nsec; Z_{in} - 1K ohms, DC coupled, for positive signals (selectable by internal jumper to 50 ohms); Z_{in} = 50 ohms, DC coupled for negative signals.

OUTPUTS

OVERLAP - front panel output provides a negative NIM logic pulse of -16mA to external 50 ohm load; rise time ⩽2nsec; width determined by overlap of the selected coincidence events.

$\overline{\text{OVERLAP}}$ - same characteristics as OVERLAP except complementary logic function.

SHAPED OUTPUTS

NEGATIVE - two independent front panel outputs provide a negative NIM logic pulse of -16mA to an external 50 ohm load for each coincidence event; rise time <2nsec; width determined by setting of front panel WIDTH control. Lower output selectable by internal jumper for complementary logic function.

POSITIVE - two independent front panel outputs provide a pulse of +5V nominal for each coincidence event; rise time <10nsec; Z_{out} = 50 ohms, width determined by setting of front panel WIDTH control. Lower output selectable by internal jumper plug for complementary logic function.

Specifications(continued)

CONTROLS

COINC/0/ANTI - front panel toggle switch adjacent to each input connector to select the logic function of that input: COINC for coincidence, 0 for off, ANTI for anticoincidence.

TRIG - front panel toggle switch to select edge of overlap period from which the shaped outputs are to be triggered.

WIDTH: OVERLAP/VAR1/VAR2 - front panel toggle switch to select the pulse width of SHAPED OUTPUTS to be same as OVERLAP, VARiable 50nsec to 1μsec (1), or VARiable 500nsec to 10μsec (2) by means of adjacent 22-turn trimming potentiometer.

PERFORMANCE

RESOLVING TIME - an input overlap of $\geqslant$3 nanoseconds will generate any or all outputs.

PULSE PAIR RESOLUTION - $<$10nsec for front panel fast OVERLAP and $\overline{\text{OVERLAP}}$ outputs in any mode: $<$20nsec for SHAPED OUTPUTS with minimum WIDTH.

COUNT RATE - $>$50MHz for fast OVERLAP and $\overline{\text{OVERLAP}}$ outputs; limited by selected width for SHAPED OUTPUTS.

OPERATING TEMPERATURE RANGE - 0° to 50°C.

CONNECTORS

All signal connectors are front panel mounted BNC type.

POWER REQUIREMENTS

+24VDC	–	0mA	+12VDC	–	85mA
- 24VDC	–	0mA	- 12VDC	–	485mA*

PHYSICAL

SIZE - standard single width NIM module (1.35 x 8.71 inches) (3.43 x 22.13 cm) per TID-20893 (rev.)

NET WEIGHT - 1.9 lbs. (0.9 kg).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs).

*This power exceeds the normal BIN power allotment of 167mA for a single width module.

LINEAR ELECTRONICS

Included in this section of the catalog are general purpose NIM instruments used for shaping and processing linear signals. To simplify the selection of the instrument that fits your need, a selection guide by application is included which references the instrument you should choose. Refer to the specification sheet for a complete description of the instrument.

APPLICATION	MODEL(S)	FEATURE(S)	REMARKS
Delay	1457	0.25 to 4.75μsec	A versatile variable gain DC coupled analog amplifier.
Linear Gate	1451	Fixed restorer coupling	Utility grade unity gain gated amplifier used to pass selected portions of the energy spectrum to the exclusion of all others.
	1454	Stretcher & pileup rejector	A single width NIM model with a linear gate, pulse stretcher and pileup rejector.
Stretcher	1454	1 to 5μs	A single width NIM model with a linear gate, pulse stretcher and pileup rejector.
Biased Amp	1461	Fixed input shape	A utility grade biased amplifier for expanding any portion of the energy spectrum across the full range of MCA memory.
	1467	Variable input shape	A research grade amplifier incorporating a pulse stretcher, baseline restorer, pileup rejector, linear gate, variable linear delay and variable output width.
Sum-Invert Amp	1465A	4 inputs	Accepts ± linear inputs, algebraically sums up to 4 inputs with adjustable gain on one input.
Livetime Correction and Pile-up Rejection	1468A	Both	Quantitative gamma ray analysis independent of count rate. Inspects for pileup & rejects convoluted pulses. A must for the best in high count rate performance.
Stabilizer	2050	High count rate	Compensates for gain shifts due to HVPS variations, count rate effects on PM tubes, temperature variations and line voltage variations. Optimized for high count rate.

Model 1451
Linear Gate

Features

- Accepts positive or negative linear inputs
- Independent gate width and delay controls
- Coincidence/anticoincidence operating modes
- Nonlinearity less than ±0.15%
- Stability better than 0.01%/°C
- DC coupled for high count rate capability

Description

The Canberra Model 1451 Linear Gate is normally used to pass selected portions of an energy spectrum, to the exclusion of all others, for subsequent pulse height analysis by a multichannel analyzer. It is frequently inserted into a system before the MCA to decrease the counting rate to (and dead time of) the analyzer. When it is required to obtain a spectrum of events that are in coincidence at two detectors, the Linear Gate can be driven from a coincidence module such as the Canberra Model 2040 so that only those events which appear simultaneously at both detectors are analyzed.

The DC coupled Model 1451 permits operation at high count rates without baseline shift and passes either polarity (unipolar or bipolar) pulses from 0 to 10 volts amplitude. The pedestal is factory calibrated to near zero. With unity gain, the Linear Gate features an integral nonlinearity of less than ±0.15% and OUTPUT stability better than 0.01%/°C.

There are three modes of operation determined by the front panel GATE MODE control: (1) in gate OFF position, all INPUT signals are enabled through the gate, (2) in gate ON mode INPUT signals are passed only when accompanied by an external gate trigger signal, (3) in gate ANTI mode, each external gating signal acts as a signal block, allowing input signals to be passed only when a gate trigger is not present.

The Model 1451 ensures linear gating (coinc/anti) any desired portion of the incoming signal by providing continuously adjustable GATE DELAY and GATE WIDTH controls, both independent of the external GATE IN signal. The only timing requirement of the gate trigger is that it should precede the linear INPUT. By front panel control, the start of the gate period may be delayed from the external GATE IN by 0.4 to 1.4 microseconds. A rear panel switch allows this gate delay to be switched out. GATE WIDTH may be selected between 0.5 and 5 microseconds, or, using a rear panel switch, between 5 and 50 microseconds. Thus, the versatility of the Model 1451 gate control circuits gives the user an unmatched control system.

Specifications

INPUTS

INPUT - accepts positive or negative 0 to 10V, unipolar or bipolar, linear pulses from most commercially available main amplifiers; rise time ≥100nsec; any width; Z_{in} ≈1.2K ohms, DC coupled; front panel BNC connector.

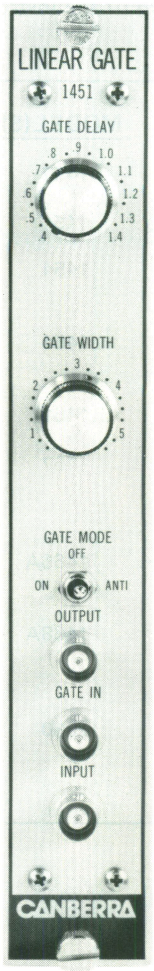
GATE IN - accepts positive 4V to 10V logic pulses; GATE INput should precede INPUT by at least 400nsec; rise time <500nsec; width ≥100nsec; Z_{in} ≈1K ohms; front panel BNC connector.

OUTPUTS

OUTPUT - provides noninverting linear output, shape identical to INPUT; unity gain; signal range 0 to ±10V; Z_o <1 ohm, DC coupled; front panel BNC connector.

CONTROLS

GATE DELAY - front panel single-turn potentiometer determines delay between the GATE IN signal and the opening (or closing) of the gate when the rear panel DELAY switch is IN; 0.4 to 1.4μsec continuously adjustable range.



GATE WIDTH - front panel single-turn potentiometer selects the gate width after opening (or closing) the gate; with multiplier, total width range is 0.5 to 50μsec, continuously adjustable.

GATE MODE - front panel 3-position toggle switch selects OFF (disables gating function), ON (coincidence), or ANTI (anticoincidence) gate mode of operation.

DELAY - rear panel toggle switch enables (IN) or disables (OUT) the GATE DELAY control; OUT position leaves a circuit delay of ≤100nsec.

WIDTH - rear panel toggle switch provides selection of X1 (0.5 to 5μsec) or X10 (5 to 50μsec) GATE WIDTH control range.

PEDESTAL ADJUST - internal single-turn screwdriver adjust potentiometer to adjust gate pedestal to zero volts; factory adjusted to <1mV.

PERFORMANCE

FEEDTHROUGH - <1% of amplitude input with gate closed.

GATE PEDESTAL - internally adjustable to <1mV.

INTEGRAL NONLINEARITY - <±0.15% for pulse rise time >100nsec.

GAIN - X1 (unity), factory calibrated.

TEMPERATURE OPERATING RANGE - 0 to +50°C ambient.

OUTPUT STABILITY - better than 0.01%/°C.

GATE WIDTH STABILITY - better than 0.25%/°C.

GATE DELAY STABILITY - better than 0.05%/°C.

Specifications(continued)

CONNECTORS

All signal connectors are front panel mounted BNC types.

POWER REQUIREMENTS

+24VDC — 10mA +12VDC — 40mA
-24VDC — 15mA -12VDC — 35mA

PHYSICAL

SIZE - standard single-width NIM module (1.35 x 8.71 inches) (3.43 x 22.13 cm) per TID-20893 (rev.).

NET WEIGHT - 2.0 lbs. (0.9 kgs.).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs.).

DELAY
IN
OUT
X1
X10
WIDTH
FINAL
BERUBE
TEST

Model 1454
Linear Gate and Stretcher

Features

- Pulse pileup rejector
- Baseline restorer
- Variable linear delay
- Variable output width
- Switch selected invert/non-inverted output

Description

The Canberra Model 1454 Linear Gate and Stretcher provides a standardized optimum shaped output for superior performance of a multichannel analyzer in high rate/high resolution nuclear spectroscopy. An extremely flexible module, the Model 1454 includes a pulse stretcher, DC coupled linear gate, DC restorer, and pulse pileup rejector.

The integral pulse stretcher portion of the Model 1454 compensates for multichannel analyzers which have stringent requirements for input pulse shapes. All main amplifier pulses are converted to a standardized linear output pulse shape, variable in width (1-5μsec) and delay time (0.5-5μsec) via front panel controls. Rectangular in appearance, the linear stretched SIGNAL OUTPUT is essentially flattopped with very little droop ($<$0.3mV/μsec). Thus, linearity of the succeeding MCA is improved where sharply peaked pulse shaping has been used in the main linear amplifier.

DC coupling, fast circuitry, selectable baseline restoration, and pileup rejection all contribute to preserve spectral resolution at high count rates. The integral DC restorer permits the use of existing amplification systems in high rate experiments and increases the count rate capabilities of the Model 1454. Pulse pileup rejection circuitry enhances high rate performance; after the input pulse has reached its peak, subsequent pulses are automatically inhibited until both the output pulse has terminated and the input recovered to the baseline.

The Model 1454 provides for strobed, or COINCidence or ANTIcoincidence gated modes of operation. Therefore, analyzer overload may be minimized without requiring additional gating modules.

DC operation of the multichannel analyzer is essential for optimum count rate performance when using the Model 1454. A rear panel PERIOD OUTPUT supplies the necessary logic information to enable DC operation of certain MCA's. Selectable output polarity and full scale output voltage range of 3, 5, or 10 volts ensures maximum MCA compatibility.

Specifications

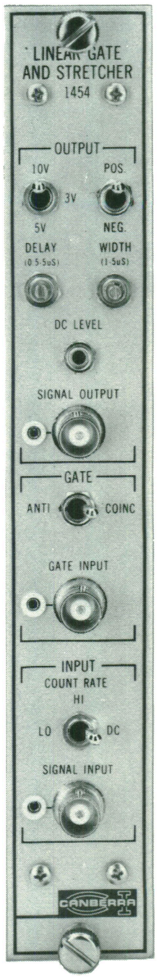
INPUTS

SIGNAL INPUT - accepts positive 0.1 to 10V unipolar or bipolar linear pulses; rise time $\geqslant$100 nanoseconds; width $\geqslant$300 nanoseconds; Z_{in} $\approx$250 ohms for 0.1V signal, $\geqslant$20K ohms over 1V; DC or DC restorer coupled.

GATE INPUT - accepts positive logic pulse or DC level, $\geqslant$3.5V ($\pm$20V max); width $\geqslant$100 nanoseconds; Z_{in} $\approx$2K ohms, DC coupled.

OUTPUTS

SIGNAL OUTPUT - provides positive or negative 0.1 to 10V essentially flattopped rectangular pulse; rise time $\approx$0.5μsec; duration and delay as selected by front panel controls; DC offset variable from - 2V to +2V; Z_O $\leqslant$0.1 ohms, DC coupled.



PERIOD OUT - +5V logic pulse, leading edge in time coincidence with SIGNAL OUTPUT; duration essentially equal to SIGNAL OUTPUT; Z_O $\approx$50 ohms, series-connected, DC coupled, rear panel.

CONTROLS

POS/NEG - front panel toggle switch to select either POSitive or NEGative output polarity, with respect to positive input.

10V/3V/5V - front panel three position toggle switch to select either 3V, 5V, or 10V full scale output for +10V input signal.

DELAY - front panel single-turn screwdriver adjust potentiometer to adjust SIGNAL OUTPUT delay time from peak of input signal when in GATED mode; 0.5 to $\geqslant$5μsec range; acts as automatic reset when in STROBE mode.

WIDTH - front panel single-turn screwdriver adjust potentiometer to vary SIGNAL OUTPUT pulse width; 1 to $\leqslant$5μsec range.

DC LEVEL -front panel 22-turn screwdriver adjust potentiometer to set the SIGNAL OUTPUT baseline between $\pm$2V, in order to match the input DC offset level of the following DC coupled instrument.

GATE - front panel two position toggle switch to select COINCidence or ANTIcoincidence gated mode of operation; output is enabled (COINC) or inhibited (ANTI) upon receipt of a positive GATE INPUT signal (pulse or DC level) any time between the beginning of the linear INPUT SIGNAL and the start of the stretched OUTPUT signal.

Specifications(continued)

COUNT RATE - front panel three position toggle switch to select straight DC, or DC restorer coupling with HI and LO rate positions.

GATED/STROBE - internal two position toggle switch to select GATED or STROBE mode of control; (shipped in GATED mode); in GATED mode, a GATE INPUT signal controls output according to GATE mode switch; in STROBE mode, output is inhibited until positive strobe signal (only pulse inputs accepted) appears at GATE INPUT connector; leading edge of strobe pulse causes output in time coincidence; strobe pulse must occur after peak of linear INPUT signal; automatic reset in absence of strobe pulse, variable 1 to 25μsec maximum.

PERFORMANCE

INTEGRAL NONLINEARITY - <±0.05%, from 0.1 to 10V output for inputs with rise time ≥200 nanoseconds.

STRETCHER DROOP - <0.3mV/μsec.

GATE FEEDTHROUGH - <0.05% of signal amplitude with gate closed.

GATE PEDESTAL - essentially zero pedestal, factory calibrated.

NOISE CONTRIBUTION - <20μV RMS, referred to input.

PILEUP REJECTION - after the input pulse has reached its peak subsequent pulses are automatically inhibited until both the output pulse has terminated and the input recovered to the baseline.

TEMPERATURE STABILITY - DC output level ≤0.1mV/°C; gain ≤0.0075%/°C.

COUNT RATE STABILITY - <0.1% pulser peak shift at 80% of full scale when modulated by 0-80kHz of random Cs^{137} with photopeak at 70% of full scale, using Model 2011 or 2010 amplifier with active filter time constant of 1μsec unipolar.

CONNECTORS

All signal connectors are BNC type.

POWER REQUIREMENTS

+24VDC — 35mA   +12VDC — 140mA
- 24VDC — 60mA   - 12VDC — 70mA

PHYSICAL

SIZE - standard single-width NIM module (1.35 x 8.71 inches). (3.42 x 22.13 cm) per TID-20893 (rev.).

NET WEIGHT - 2.0 lbs. (0.9 kgs).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs.).

Model 1457
Delay Amplifier

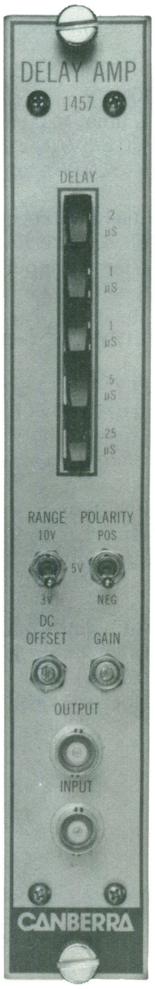
Features

- Adjustable linear or logic delay from 0.25 to 4.75 microseconds
- Inverted or non-inverted output selection
- Output range control: 3V, 5V or 10V
- Gain normalizing control
- DC offset control

Description

The Canberra Model 1457 Delay Amplifier can delay logic or linear signals up to 4.75 microseconds in 0.25 microsecond steps. The Delay Amplifier has a gain of unity, adjustable by front panel control. The input signal may be of either polarity and an inverted or non-inverted output may be selected by means of a front panel switch.

The output full scale signal range is selected by front panel control to be 3, 5, or 10 volts for a 10 volt input signal. The amount of delay is pushbutton-selected by inserting any combination of five delay lines (0.25, 0.5, 1.0, 1.0, or 2.0 microseconds) in series with the signal of interest. The Model 1457 is DC coupled to give optimum performance at high count rates. The output DC level is adjustable by front panel control.



Specifications

INPUTS

INPUT - accepts positive or negative signal from 0 to 10 volts amplitude; input impedance is ≈1K ohms, DC coupled; front panel BNC connector.

OUTPUTS

OUTPUT - provides positive or negative signal; amplitude and delay determined by front panel switch settings; output impedance is ⩽1 ohm; DC coupled; front panel BNC connector.

CONTROLS

DELAY (µsec) - five pushbuttons to select any combination of 0.25, 0.5, 1.0, 1.0 or 2.0 microseconds delay increments.

RANGE - three-position toggle switch selects output range for 3, 5, or 10 volts full scale for 10 volt input.

POLARITY - toggle switch to select an output which is either inverted (NEG) or non-inverted (POS) with respect to the INPUT.

DC OFFSET - single-turn screwdriver adjustment offsets the DC level of the OUTPUT signal, range is ±2 volts.

GAIN - single-turn screwdriver adjustment varies gain to obtain unity gain for all ranges of input shaping.

PERFORMANCE

LINEAR DELAY - any combination of 0.25, 0.5, 1.0, 1.0, and 2.0 microseconds.

GAIN CONSTANCY - ⩽±4% for any combination of delays (2µsec near-Gaussian shaped pulse).

FEEDTHROUGH AND DELAY RIPPLE - <±1% (1µsec near-Gaussian shaped pulse).

MINIMUM DELAY - 150 nanoseconds (residual).

DELAY LINE TOLERANCES - ⩽±5%.

RISE TIME AS A FUNCTION OF DELAY:

DELAY (microseconds)	RISE TIME (nanoseconds)
0	≈200
0.5	≈400
1.0	≈420
2.0	≈450
4.0	≈500

GAIN STABILITY - ⩽±0.003%/°C/µsec delay. 0 to 50°C.

NONLINEARITY - ⩽±0.05% from 0.1 to 10 volts.

DC LEVEL STABILITY - ⩽±0.5mV/°C @ nom, 0VDC, 0 to 50°C.

CONNECTORS

Signal connectors are front panel mounted BNC types.

POWER

+24VDC —	35mA	+12VDC —	15mA
- 24VDC —	45mA	- 12VDC —	15mA

PHYSICAL

SIZE - standard single-width NIM module (1.35 x 8.71 inches) (3.43 x 22.13 cm) per TID-20893 (rev).

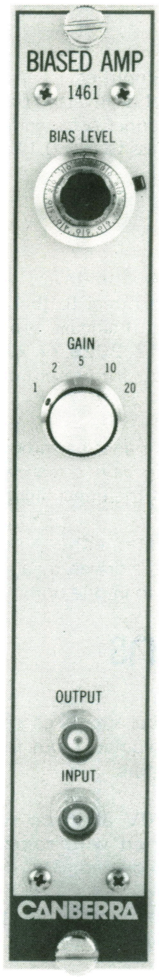
NET WEIGHT - 2.2 lbs. (1.0 kg).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs.).

Model 1461 Biased Amplifier

Features

- Spectrum expansion
- DC restorer coupled
- Post gain to X20



Description

The Model 1461 Biased Amplifier accepts 0 to +10 volt, unipolar or bipolar signals from any commercially available main shaping amplifier and, via the front panel controls, expands any portion of the energy spectrum across the full range of a multichannel analyzer.

The energy level above which spectrum expansion is to occur is selected by the front panel BIAS LEVEL control. Post gain of the spectrum above this energy level is selected by the front panel GAIN control; X1, X2, X5, X10, or X20. The bias cut point is translated to the zero point of the analyzer spectrum; the spectrum above this point is then accumulated by the analyzer, expanded by the post gain factor selected.

For example, if a ^{60}Co spectrum were displayed on a 400 channel analyzer, the 1.17MeV peak might be three channels wide, centered in channel 234. The 1.33MeV peak might be a 3.5 channels wide, centered in channel 266. By setting the BIAS LEVEL to 1.15MeV and the GAIN control to X10, the spectrum would be expanded so that 1.17MeV peak would appear centered about channel 40, 25 channels wide; the 1.33MeV peak would appear centered about channel 360, 30 channels wide.

The Model 1461 is thus particularly useful where the multichannel analyzer is the limiting factor in system resolution, where a considerably larger analyzer would be desirable. Using the Model 1461, a selected portion of the spectrum may be examined in the same detail that would be possible with an analyzer with from 2 to 20 times more channels.

Specifications

INPUTS

INPUT - accepts 0 to +10 volt unipolar or bipolar (positive lobe leading) linear pulses; RC, delay line, or near-Gaussian shaped $Z_{in} = \approx 500$ ohms, DC restorer coupled; front panel BNC connector.

OUTPUTS

OUTPUT - 0 to 9.9 volt positive linear pulse; $Z_o = <1$ ohms, DC coupled; front panel BNC connector.

PERFORMANCE

INTEGRAL NONLINEARITY - $\leqslant \pm 0.1\%$ from 0.2 volts to 10 volts with BIAS LEVEL at zero.

GAIN STABILITY - better than $\pm 0.01\%/^{o}C$.

BIAS LEVEL STABILITY - better than $\pm 0.6mV/^{o}C$.

NOISE - $\leqslant 3$ millivolts RMS, any gain setting, in the absence of an input.

CONTROLS

BIAS LEVEL - 0-9 volts, adjustable by ten-turn locking dial potentiometer.

GAIN - steps of 1, 2, 5, 10, 20, switch selected, for amplification of the portion of INPUT signal above bias level.

CONNECTORS

SIGNALS - all signal connectors are front panel mounted BNC types.

POWER REQUIREMENTS

+24VDC — 15mA +12VDC — 20mA
- 24VDC — 55mA - 12VDC — 20mA

PHYSICAL

SIZE - standard single-width NIM module (1.35 x 8.71 inches) (3.42 x 22.13 cm) per TID-20893 (rev).

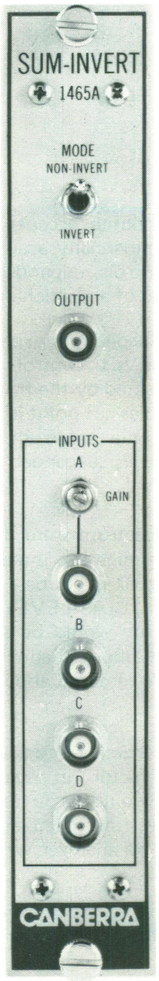
NET WEIGHT - 2.3 lbs. (1.04 kgs.).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs.).

Model 1465A
Sum-Invert Amplifier

Features

- Four-input summing amplifier
- Switch selected normal or inverted output
- Adjustable gain on channel A for gain equalization
- Integral nonlinearity less than ±0.1%
- Fully DC coupled



Description

The Canberra Model 1465A Sum-Invert Amplifier provides a linear output signal which is proportional to the algebraic sum of up to four linear unipolar or bipolar input signals, typically from linear amplifiers such as Canberra Model 2012, 2020, or 2011. The Model 1465A also serves to mix up to four inputs for presentation to a single input such as a multichannel analyzer.

A gain control on the front panel permits the gain of INPUT A to be varied by ±25%, permitting gain equalization at the input without necessitating readjustment of the linear signal source.

Via front panel switch selection, either a normal or an inverted output may be selected. The output is driven by a low impedance driver having an output impedance of less than one ohm.

Specifications

INPUTS

INPUTS - four front panel inputs accept 0 - ±10V signals (±12V maximum); unipolar or bipolar, input impedance ≈1K ohms each; DC coupled, BNC connectors.

OUTPUTS

OUTPUT - provides 0-10V algebraic sum of inputs, unipolar or bipolar; normal or inverted with respect to the INPUTs; output impedance ⩽1 ohm; DC coupled, BNC connector.

CONTROLS

GAIN (INPUT A) - front panel single-turn screwdriver adjustable potentiometer permits gain equalization of the input signal at INPUT A, variable by ±25%.

MODE - front panel toggle switch to select an output which is either INVERTed or NON-INVERTed with respect to the sum of the INPUTs.

PERFORMANCE

NONLINEARITY - Integral nonlinearity ⩽±0.1% from 0.2V to 10V.

OPERATING TEMPERATURE - 0 - 50°C.

TEMPERATURE STABILITY - better than ±0.01%/°C.

GAIN - nominal unity gain on all inputs; INPUT A is variable by ±25% via the front panel screwdriver adjustment.

CONNECTORS

All signal connectors are front panel mounted BNC type.

POWER REQUIREMENTS

+24VDC — 25mA +12VDC — 15mA
- 24VDC — 25mA - 12VDC — 15mA

PHYSICAL

SIZE - standard single-width NIM module per TID-20893 (1.35 inches x 8.71 inches) (3.43 x 22.13 cm) per TID-20893 (rev.).

NET WEIGHT - 2.2 lbs. (1 kgs).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs).

Model 1467
Biased Amplifier

Features

- 0 - 10VDC biasing of input
- Variable post amplification
- Baseline restorer
- Built-in pileup rejector
- Linear gate with pulse stretcher
- Variable linear delay
- Variable output width

Description

The Model 1467 Biased Amplifier is designed to meet the requirements of high rate/high resolution nuclear spectroscopy systems. Biased amplification, linear stretched output, baseline restoration, pileup rejection, and linear gate operation are all combined in one dual-width NIM package.

Expansion of any desired portion of an energy spectrum is accomplished with the front panel BIAS LEVEL and post gain controls. This feature effectively extends the resolving capabilities of any multichannel analyzer. The variable bias level (0 - 10 volts) determines the energy level of the linear input signals above which post amplification (X1 - X24) will occur.

The integral pulse stretcher portion of the Model 1467 compensates for the incompatibility of multichannel analyzers which have stringent requirements for input pulse shapes. All main amplifier pulses are converted to a standardized linear output pulse shape, variable in width (1 - 5μsec) and delay time (0.5 - 5μsec) via front panel controls. Rectangular in appearance, the linear stretched output is essentially flat topped with very little droop ($<$1mV/μsec). Thus, linearity of the succeeding MCA is improved where sharply peaked pulse shaping has been used in the main linear amplifier.

Total DC coupling, fast circuitry, baseline restoration, and pileup rejection all contribute to preserve spectral resolution at high count rates. The integral DC restorer permits the use of existing amplification systems in high rate experiments and increases the count rate capabilities of the Model 1467. Pulse pileup rejection circuitry enhances high rate performance; after the input pulse has reached its peak, subsequent pulses are automatically inhibited until both the output pulse has terminated and the input recovered to the baseline. A limiter circuit prevents saturated output pulses (commonly occurring when using high post gain) from being presented to the MCA.

The Model 1467 provides for strobed, or COINCidence or ANTIcoincidence gated modes of operation. Therefore, analyzer overload may be minimized without requiring additional gating modules.

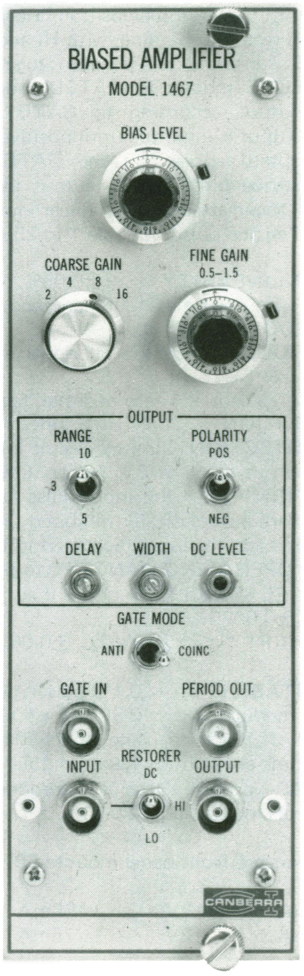
DC operation of the multichannel analyzer is essential for optimum count rate performance when using the Model 1467. A front panel PERIOD OUTput supplies the necessary logic information to enable DC operation of certain MCA's. Selectable output POLARITY and full scale output voltage RANGE of 3, 5, or 10 volts ensures maximum MCA compatibility.

Specifications

INPUTS

INPUT - accepts positive 0.1 to 10V unipolar or bipolar linear pulses; rise time $\geq$100 nanoseconds; width $\geq$300 nanoseconds; Z_{in} $\approx$250 ohms for 0.1V signal, $\geq$20K ohms over 1V; DC or DC restorer coupled.

GATE IN - accepts positive logic pulse or DC level, $\geq$3.5V ($\pm$20V max); width $\geq$100 nanoseconds; Z_{in} $\approx$2K ohms, DC coupled.



OUTPUTS

OUTPUT - provides positive or negative 0.1 to 10V essentially flat topped rectangular pulse, rise time $\approx$0.5μsec; duration and delay as selected by front panel controls; DC offset variable from - 2V to +2V; Z_o $\leq$0.1 ohms, DC coupled.

PERIOD OUT - +5V logic pulse, leading edge in time coincidence with signal OUTPUT; and duration essentially equal to signal OUTPUT; Z_o $\approx$50 ohms, series-connected, DC coupled.

CONTROLS

BIAS LEVEL - front panel ten-turn locking dial precision potentiometer, variable 0 to 10V range; resetability $\leq$0.1%.

COARSE GAIN - front panel switch selectable, with post gain of 2, 4, 8, or 16, multiplied by FINE GAIN control setting.

FINE GAIN - front panel ten-turn locking dial precision potentiometer, variable post gain of 0.5 to 1.5.

POLARITY - front panel toggle switch to select either POSitive or NEGative output polarity, with respect to positive input.

RANGE - front panel three position toggle switch to select either 3V, 5V, or 10V full scale output for +10V input signal.

DELAY - front panel single-turn screwdriver adjust potentiometer to adjust signal OUTPUT delay time from peak of input signal in the GATED mode; 0.5 to $\geq$5μsec range; acts as automatic reset in STROBE mode.

WIDTH - front panel single-turn screwdriver adjust potentiometer to vary signal OUTPUT pulse width; 1 to $\geq$5μsec range.

Specifications(continued)

DC LEVEL - front panel 22-turn screwdriver adjust potentiometer to set the signal OUTPUT baseline between ±2V, in order to match the input DC offset level of the following DC coupled instrument.

GATE MODE - front panel two-position toggle switch to select COINCidence or ANTIcoincidence gated mode of operation; output is enabled (COINC) or inhibited (ANTI) upon receipt of a positive GATE INput signal (pulse or DC Level) anytime between the beginning of the linear input signal and the start of the stretched OUTPUT signal.

RESTORER - front panel three-position toggle switch to select straight DC, or DC restorer coupling, with HI and LO rate positions.

GATED/STROBE - internal two-position toggle switch to select GATED OR STROBE modes; in GATED mode, a GATE INput signal controls output according to GATE MODE switch; in STROBE mode, output is inhibited until positive strobe signal (only pulse inputs accepted) appears at the GATE INput connector; leading edge of strobe pulse causes output in time coincidence; strobe pulse must occur after peak of linear input signal; automatic reset in absence of strobe pulse, variable 1 to 25μsec maximum.

PERFORMANCE

INTEGRAL NONLINEARITY - $<\pm 0.05\%$, from 0.1 to 10V output for inputs with rise time ≥ 200 nanoseconds.

STRETCHER DROOP - <1mV/μsec.

GATE FEEDTHROUGH - $<0.05\%$ of signal amplitude with gate closed.

GATE PEDESTAL - essentially zero pedestal, factory calibrated.

NOISE CONTRIBUTION - $<20\mu$V RMS, referred to input.

OVERLOAD PROTECTION - limited circuit inhibits output pulses above full scale output range of 3V, 5V or 10V.

PILEUP REJECTION - after the input pulse has reached its peak, subsequent pulses are automatically inhibited until both the output pulse has terminated and the input recovered to the baseline.

TEMPERATURE OPERATING RANGE - 0 to 50°C.

OUTPUT DC LEVEL STABILITY - better than ±0.2mV/°C.

GAIN DRIFT - $\leq \pm 0.0075\%$/°C.

BIAS LEVEL DRIFT - $\leq \pm 30$mV/°C ±0.002%/°C of of BIAS LEVEL setting.

COUNT RATE STABILITY - $<0.1\%$ pulser peak shift at 80% of full scale when modulated by 0-80kHz of random Cs^{137} with photopeak at 70% of full scale, using Model 2010 or 2011 amplifier with active filter time constant of 1μsec unipolar.

POST BIAS GAIN - variable X1 to X24, product of COARSE and FINE GAIN controls; resetability $\leq 0.01\%$.

CONNECTORS

All signal connectors are front panel mounted BNC type.

POWER

+24V — 75mA +12V — 155mA
-24V — 85mA -12V — 75mA

PHYSICAL

SIZE - standard double-width NIM module (2.70 x 8.71 inches) (6.85 x 22.13 cm) per TID-20893 (rev).

NET WEIGHT - 2.5 lbs. (1.1 kgs.).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs).

OPTIONS

BIAS LEVEL STABILIZER INPUT - permits positive or negative DC input signal to control Bias Level (compatible with Model 8200 Digital Stabilizer); sensitivity - 20mV Bias Level change/1V input; DC coupled, rear panel BNC connector.

Model 1468A
Live-Time Corrector Pile-Up Rejector

Features

- Combination pile-up rejector, live-time corrector for γ-Ray spectroscopy
- Provides live-time correction for quantitative analysis
- Easy-to-use calibration to optimize system performance
- Standardized output pulse compatible with all multichannel analyzers
- Rise time rejection circuit for poor charge collected signals
- Coincidence and anticoincidence gating

Description

The Canberra Model 1468A Live-Time Corrector Pile-up Rejector provides the capability of quantitative gamma spectrum analysis effectively independent of system count rate. By combining several functions into one easy to use two width module we can: inspect for pile-up and reject convoluted pulses; inspect for poor charge collection characteristics and reject unwanted pulses; correct the live-time clock for the amplifier, pile-up rejector, and ADC dead time with a unique live time correction circuit; shape the output pulse so it can be accepted by any MCA; coincidence or anticoincidence gate the signal.

The pulse pile-up rejector allows the output of only those signals which result from a single energy event in the detector during the processing time of the spectroscopy amplifier. It is capable of discriminating between two events separated by at least 500nsec. for energies equivalent to 0.5MeV.

To compensate for the counts lost, a system dead time is derived and generated by the live-time correction function. This dead time signal controls a "live-time" clock which will extend collection time by the appropriate amount. For input count rates up to 15,000 counts per second, the integrated area of a full energy peak will typically change less than 1%. The number of counts processed per unit corrected time compared to the actual count rate will typically differ by 0.5% up to 40,000 counts per second.

The dead-time of the ADC in the multi-channel analyzer and that associated with the amplifier are automatically accounted for when the 1468A is the dominant controller over the system clock. This is accomplished by connecting the ADC Dead Time to the 1468A and the 1468A System Busy Time to the MCA or Live Timer.

Specifications

INPUTS

AMP IN - Linear signal 0 to +10V from associated Model 2020 Spectroscopy Amplifier or equivalent.

PREAMP IN - Linear signal; 0 to 5V; Pos or Neg. switch selectable; from associated Model 2001 Preamplifier, or equivalent.

ADC DEAD TIME

POS - TTL compatible input; logical 1 is busy, logical 0 otherwise.

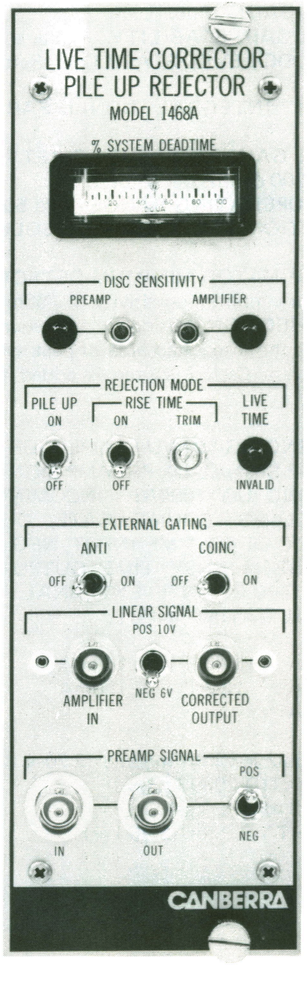
NEG - TTL compatible input; logical 0 is busy; logical 1 otherwise.

EXTERNAL GATING

ANTI - TTL compatible logical 0 = process, logical 1 = inhibit; edge or level triggered, must occur before the peak of the amplifier linear signal.

COINC - TTL compatible logical 0 = inhibit; logical 1 = process; edge or level triggered, must occur before the peak of the amplifier linear signal.

COINC enables the corrected output, while ANTI coinc disables the corrected output; both functions are independent of one another. There is no Live Time correction for pulse rejected due to external gating.



OUTPUTS

CORRECTED OUTPUT - Linear signal; DC coupled; rectangular positive or negative pulse; 0.1V to 10V or - 0.05 to - 6V, front panel selectable; 2.5μsec width; t_r = 0.5μsec; Z_{out} - 93 ohms or 0.1 ohm internally selected; 0 ±20mV DC level. Occurs ≈100nsec past the peak of the amplifier input signal.

PREAMP SIGNAL OUT - Direct connection to Preamp In signal.

SYSTEM BUSY TIME

POS - +5V nominal DC level while system is dead, OV nominal otherwise; $t_r \leqslant$100nsec; Z_{out} = 51 ohms.

NEG - 0V nominal DC level while system is dead, +5V nominal otherwise; $t_r \leqslant$100nsec; Z_{out} = 51 ohms.

COUNT RATE INCOMING - +5V nominal pulse, $t_r \leqslant$100nsec, P.W. 150nsec nominal; Z_{out} = 51 ohms.

COUNT RATE OUTGOING - +5V nominal pulse; $t_r \leqslant$100nsec; P.W. 2.5μsec nominal, Z_{out} = 51 ohms.

FRONT PANEL CONTROLS

DISC SENSITIVITY - PREAMP and AMPLIFIER — 22-turn screwdriver adjustments of the discriminator levels from 0 to approximately 150mV and 800mV respectively; associated lamps are used to optimize adjustments.

REJECTION MODE

PILE-UP - 2-position toggle to activate pile-up rejector.

RISE TIME - 2-position toggle to activate rise time rejection; single turn TRIM control to adjust rise time rejection criteria; INVALID lamp is illuminated when using Rise Time rejection.

Specifications(continued)

EXTERNAL GATING

ANTI - 2-position toggle to activate anticoincidence gating circuits.

COINC - 2-position toggle to activate coincidence gating circuits.

LINEAR SIGNAL - 2-position toggle to select linear output range 0 to 10V or 0 to - 6V.

PREAMP SIGNAL - 2-position toggle to select preamp input signal polarity.

PERFORMANCE

LINEAR SIGNAL GAIN - Unity ±3%.

LINEAR SIGNAL GAIN STABILITY - Better than 0.007% per °C.

LINEAR SIGNAL DC LEVEL STABILITY - Better than 150μV per °C.

LINEAR SIGNAL INTEGRAL NONLINEARITY - Less than 0.025%.

LINEAR SIGNAL GAIN AND LEVEL SHIFT - Less than 0.075% of full scale at 50,000 counts per second.

TEMPERATURE OPERATING RANGE - 0 to 50°C ambient.

PILE UP REJECTION PULSE PAIR RESOLUTION - 500nsec minimum.

PREAMP DISCRIMINATOR MINIMUM DETECTABLE ENERGY - 20keV [based on preamplifier sensitivity of 100mV/MeV (Ge)].

LIVE TIME CORRECTION - Using a Zn-65 source providing 1000 counts per second, the integrated area of peak will typically change less than 1% when a Cs-137 source is added to provide 15,000 counts per second.

CONNECTORS

FRONT PANEL BNC UG 1094/U - AMPLIFIER IN, CORRECTED OUTPUT, PREAMP SIGNAL IN, PREAMP SIGNAL OUT.

REAR PANEL BNC UG 1094/U - INCOMING COUNT RATE OUTPUT, OUTGOING COUNT RATE OUTPUT, LINEAR OUTPUT, POS ADC DEAD TIME INPUT, NEG ADC DEAD TIME INPUT, POS SYSTEM BUSY TIME OUTPUT, NEG SYSTEM BUSY TIME OUTPUT, ANTI EXTERNAL GATING INPUT, COINC EXTERNAL GATING INPUT.

POWER

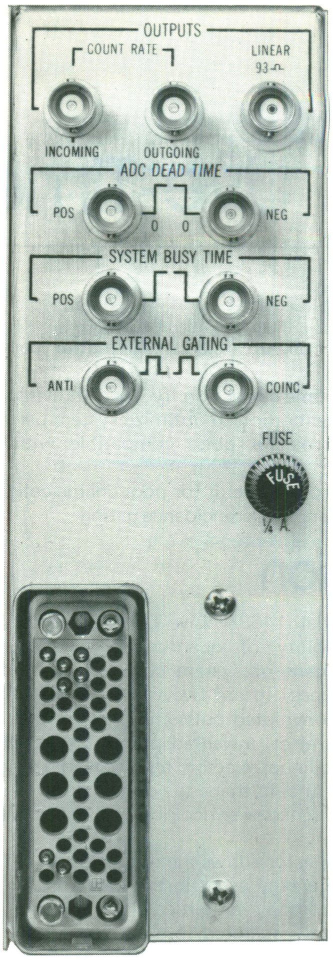
+24V	—	30mA	+12V	—	160mA
- 24V	—	25mA	- 12V	—	180mA
115VDC	—	60mA			

PHYSICAL

SIZE - Standard double-width module (2.70 x 8.714 inches) (6.85 cm x 22.13 cm) per TID 20893 (Rev.)

NET WEIGHT - 3.8 lbs (1.7 kgs)

SHIPPING WEIGHT - 8.8 lbs (3.96 kgs)



Model 2050
Spectrum Stabilizer

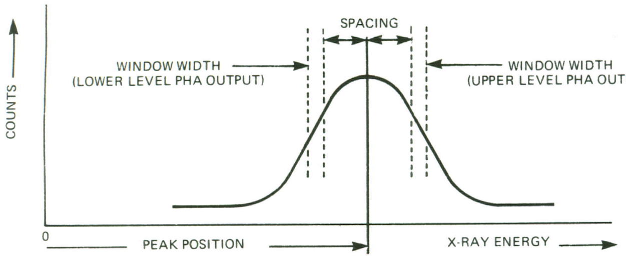
Features

- Maintains system gain stability at any count rate
- Eliminates long term drift
- Compensates for gain changes from - 50% to +100%
- No external feedback required

Description

The Canberra Model 2050 provides fast and accurate correction for gain shifts occurring anywhere in an X-ray system (detector, high voltage power supply, preamplifier, amplifier). The Model 2050 ensures drift free data acquisition over indefinitely long collection times. It is particularly useful in compensating for the baseline shift which occurs in most amplifiers at high count rates. The Stabilizer also eliminates the high count rate gain shift inherent in gas proportional detectors.

All gain corrections are made within the Stabilizer, requiring no external feedback to other components of the system. The Model 2050 exhibits a gain stability of ±0.05% while correcting for system gain shifts as large as - 50% to +100%. The only count rate restriction placed on the Stabilizer is that the counts in the windows must be greater than the rate of drift being corrected.



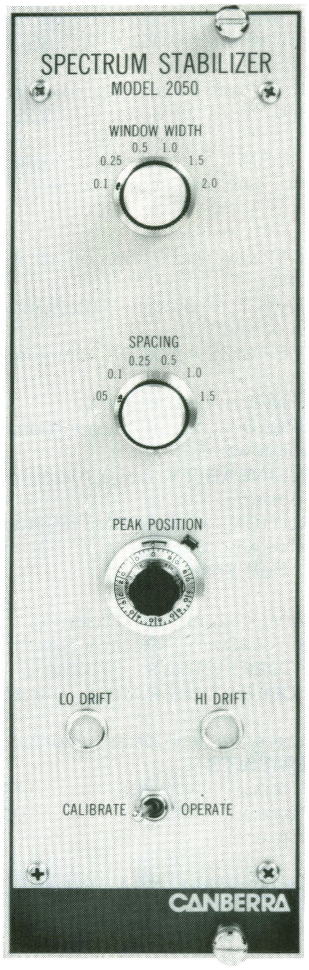
The Model 2050 requires a peak in the X-ray spectrum to use as a reference for stabilization. Two highly stable energy windows are established symmetrically on the sides of the reference peak using the front panel Peak Position, Spacing, and Window Width controls. In the absence of system gain shift, the number of counts detected in each window will be essentially equal. When a system drift occurs, one window will accumulate more counts than the other, causing the stabilizer gain to increase or decrease by the appropriate amount to correct for the gain change. The direction of gain shift at any moment is indicated by the front panel Hi and Lo Drift lights. For initial setup purposes, auxiliary Lower and Upper Level PHA (window) Outputs are available on the rear panel.

For optimum performance in high count rate applications, the Model 2050 Stabilizer should be used with Canberra's Model 1718 X-ray Amplifier/PHA.

Specifications

INPUTS

SIGNAL INPUT - accepts positive 0 to 10V delay-line, RC, or Gaussian shaped linear pulses from most commercially available transistorized main amplifiers; $Z_{in} \approx 1$K ohms, DC coupled, rear panel BNC connector



OUTPUTS

SIGNAL OUTPUT - provides gain-corrected 0 to 10V linear output pulses for subsequent analysis; shape and polarity identical to Signal Input; $Z_o < 1$ ohm, short-circuit protected, DC coupled, rear panel BNC connector

LOWER LEVEL PHA OUTPUT - provides an auxiliary logic output for each input pulse height within the lower window; +8V amplitude; rise and fall time $\leqslant$25nsec; width $\approx$50nsec; $Z_o < 20$ ohms; short-circuit protected, DC coupled, rear panel BNC connector

UPPER LEVEL PHA OUTPUT - provides an auxiliary logic output for each input pulse height within the upper window; +8V amplitude; rise and fall time $\leqslant$25nsec; width $\approx$50nsec; $Z_o < 20$ ohms; short-circuit protected, DC coupled, rear panel BNC connector

Specifications(continued)

CONTROLS/INDICATORS

CALIBRATE/OPERATE - front panel toggle switch to enable or disable the Model 2050 from making gain corrections. CALIBRATE position permits the system to function without gain stabilization and resets the stabilizer to nominal X1 gain for setup purposes

PEAK POSITION - front panel ten-turn precision potentiometer selects centroid position of energy peak to be stabilized and serves as gain shift reference; 0 to +10V range

SPACING - front panel six-position rotary switch symmetrically selects position of lower and upper windows with respect to PEAK POSITION control setting; 0.05, 0.1, 0.25, 0.5, 1.0, and 1.5V positions

WINDOW WIDTH - front panel six-position rotary switch selects width of lower and upper windows; 0.1, 0.25, 0.5, 1.0, 1.5, and 2.0V positions

LOW DRIFT/HI DRIFT - front panel indicator lights serve to indicate direction of gain shift at any moment; helpful during initial setup

PERFORMANCE

GAIN STABILIZATION - ±0.05% of total system gain with stabilizer gain of one

CORRECTION RANGE - - 50% to +100% maximum gain change with stabilizer gain of one

CORRECTION STEP SIZE - ±0.05% minimum with stabilizer gain of one

COUNT RATE RANGE - no restrictions

CORRECTION SPEED - directly proportional to count rate in lower and upper windows

AMPLIFIER NONLINEARITY - ⩽0.1 integral from 0.2 to 10V output (Calibrate position)

NOISE CONTRIBUTION - <50µV RMS referred to input

CALIBRATE GAIN - X1 ±5%

ACCURACY (% of Full Scale)

PEAK POSITION - <±100mV

SPACING - <±50mV; <±25mV for 0.5 setting

WINDOW WIDTH - <±100mV; <±50mV for 0.1 setting

TEMPERATURE COEFFICIENT - <0.02%/°C

TEMPERATURE OPERATING RANGE - 0 to 50°C

CONNECTORS

All signal connectors are rear panel mounted BNC type.

POWER REQUIREMENTS

+24VDC — 55mA
- 24VDC — 45mA
115VAC — 65mA
+12VDC — 110mA
- 12VDC — 100mA

PHYSICAL

SIZE - standard double-width NIM module (2.70 x 8.71 inches) (6.85 cm x 22.13 cm) per TID-20893 (rev.)

NET WEIGHT - 2.0 lbs. (0.9 kgs)

SHIPPING WEIGHT - 7.0 lbs. (3.15 kgs)

RATEMETER INTRODUCTION

This section is devoted to the introduction and explanation of Canberra ratemeters to assist in the proper selection for your particular application.

A ratemeter is an instrument that measures and displays an average count rate. In a system, it is often used with a single channel analyzer to determine the frequency of occurrence of nuclear events of specific energy. The ratemeter is also useful for system set-up by indicating whether or not the instruments preceding it are processing signals.

In a ratemeter, the rate of input is determined by counting the number of pulses that occur over a certain period of time. It is similar to a counter and timer combination; however, the ratemeter performs this determination through analog means and displays the results on a meter directly, in counts per second. In the counter/timer combination, the timer controls the amount of time for which the collection of counts will occur. In the ratemeter, the choice of time constants determines the integration time over which the averaging occurs. The integrator signal is converted to meter current. If the time constant chosen is too long, fast input rates and transients will not be observed accurately. If the time constant is too short, the ratemeter will respond to fluctuations of input count rate. Thus, time constant selection is an extremely important parameter to consider when determining which ratemeter to choose for a particular application.

Other salient features to consider are the ratemeter's count rate range, zero offset and background subtraction capabilities, input voltage range, linearity, recorder output voltage, readout accuracy and the type of display. The following selection chart lists the Canberra ratemeters detailing each of the salient features.

Model #	Type of Display	Count Rate Range (# of Ranges)	Input Range	Zero Offset or Background Subtraction	Linearity	Readout Accuracy		Recorder Output Voltage	Time Constants or Standard Deviation Selection	Temperature Drift
						Meter	Recorder			
2081	Linear	10 to 10,000,000 cps (7)	+2.5 to +5V or -.6 to -2V	Zero Offset	±0.3% of Range Selected	±2%	±2%	0 to +5V	3 sec on 10,100 range 1.5 sec on 1000, 10,000 range	<0.02%/°C 0-45°C
1481L	Linear and Logarithum	Linear: 10 to 500K (10) Log: 100 to 100K cps (2)	1 to 10V Positive or Negative	—	±.5% of Range Selected	±3%	±1%	0 to 100mV	.5, 2, 10 and 40 Time Constant	<1% 0-50°C

Model 1481L
Lin/Log Ratemeter

Features

- Two log full scale ranges
- Ten linear full scale ranges
- Large panel meter
- Alarm relay option

Description

The Canberra Model 1481L Lin/Log Ratemeter offers the user a choice of either linear or logarithmic presentation, via a front panel meter, of the average number of pulses per second being received at the front panel input.

In the linear mode, the Model 1481L features ten full scale ranges, from 10 to 500,000 counts per second, permitting accurate reading at any range, or the choice of an extremely wide dynamic input range. In this mode, the input pulse rate may be integrated over any one of four switch-selectable time constants, from 0.5 to 40 seconds.

In the logarithmic mode, the Model 1481L features two 3-decade ranges, from 10 to 10^4 counts per second, and from 10^2 to 10^5 counts per second, permitting the user to monitor a wide dynamic input range without the necessity of changing control settings.

An Alarm Relay option is available, enabling the Model 1481L to trigger an alarm (choice of enable or inhibit operation) whenever the count rate exceeds a pre-selected linear percentage of any full scale range.

The Model 1481L offers ±0.5% linearity, a rear panel 0-100 millivolt recorder output, and a 3% precision front panel meter.

Specifications

INPUTS

SIGNAL INPUT - 1 to 10 volts, positive or negative, unipolar or bipolar; minimum width 150 nanoseconds; input impedance 1000 ohms; front panel BNC connector

OUTPUTS

READOUT - front panel 2-1/2″ meter; ten full scale linear ranges from 10 to 500K counts per second; two 3-decade log ranges, 10 to 10^4 counts per second, and 100 to 10^5 counts per second

RECORDER OUTPUT - 0-100 millivolts; rear panel BNC connector

CONTROLS

LINEAR RANGE - front panel rotary switch to select linear range of 10^1, 10^2, 10^3, 10^4, or 10^5, counts per second; operative only in LIN mode

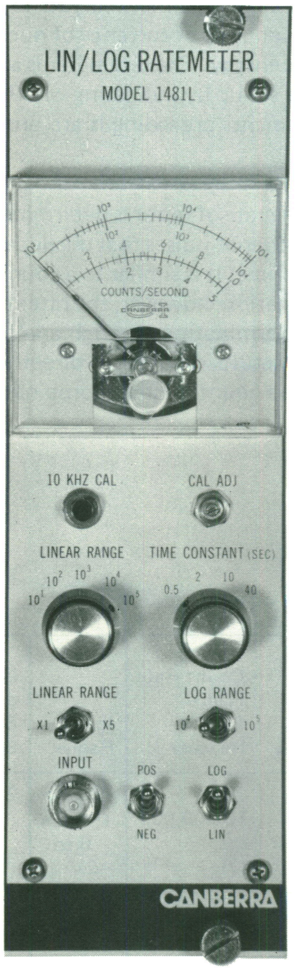
LINEAR RANGE MULTIPLIER - front panel toggle switch allows multiplication of selected linear range by a factor of 1 or 5

TIME CONSTANT - front panel rotary switch selection of 0.5, 2, 10, or 40 seconds; operative in LIN mode only (in LOG mode, time constant is composite, dependent upon input count rate)

INPUT POS/NEG - front panel toggle switch to select positive or negative input polarity

LOG/LIN - front panel toggle switch to select LINEAR or LOG mode of operation

LOG RANGE - front panel toggle switch to select full scale log range of 10^4 or 10^5



RECORDER RANGE - rear panel single-turn screwdriver adjust potentiometer to adjust recorder full scale output over a range of 0-100 millivolts

10kHz CAL - front panel pushbutton permits instantaneous check on accuracy of meter reading

CAL ADJ - front panel single-turn screwdriver adjust potentiometer to calibrate front panel meter

PERFORMANCE

RANGE - ten full scale linear range steps from 10 to 500,000 counts per second; two full scale log ranges of 10^4 and 10^5 counts per second

LINEARITY - ±0.5% of selected full scale range

READOUT ACCURACY - meter 3%; RECORDER OUTPUT, 1%

Specifications(continued)

PULSE PAIR RESOLUTION - less than 200 nanoseconds for 500,000 counts per second range; less than 2 milliseconds for 10 counts per second range

TEMPERATURE STABILITY - less than ±0.1%°C drift over 0 to 50° range

CONNECTORS

SIGNAL INPUT - front panel BNC UG-1094/U

RECORDER OUTPUT - rear panel BNC UG-1094/U

POWER

+12V — 0mA
- 24V — 0mA
+12V — 100mA
- 12V — 100mA

PHYSICAL

SIZE - standard dual width module (2.70 inches wide) (6.25 cm) per TID-20893

NET WEIGHT - 4.2 lbs. (1.9 kgs.)

SHIPPING WEIGHT - 9.2 lbs. (4.14 kgs).

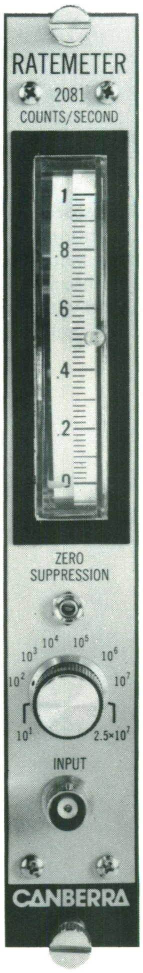
OPTIONS

ALARM RELAY - the operator can select a frequency (via rear panel 10-turn precision potentiometer) which will either close or open a set of relay switch contacts available on the rear panel; relay SPDT, contacts rated at 1 amp. (ALARM NC - C - NO). Thus, an external alarm can be sounded when the incoming pulse rate either rises above or falls below a selected frequency. Specify Model *1481* LA.

Model 2081
Linear Ratemeter

Features

- Eight Ranges, from 10 to 25,000,000 counts/second.
- Zero Suppression - front panel screwdriver adjust covers 25% of range selected.
- Fixed Time Constants on four ranges, 3 sec. on 10 and 100 counts per sec. ranges and 1.5 sec. on 1000 and 10,000 counts per sec. ranges.
- Digital rate measurement technique provides identically accurate rate determinations for each position of the range switch.
- Large 2-3/4 inches (7 cm) meter.



Description

The Canberra Model 2081 Linear Ratemeter is an accurate, highly stable count-rate meter which presents, via a front panel 2-3/4 inch (7 cm) scale edge-reading meter, the average number of pulses per second being received at the input. The digitally based instrument supplies rate updates to arithmetic logic which supplies inputs to the digital-to-analog converter driving the meter/recorder outputs.

The Model 2081 features 7 full scale ranges from 10 to 10,000,000 counts per sec. and an extra range (not full scale) extending the count rate range to 25,000,000 counts per second.

Time constants are provided on the lower four ranges and are 3 seconds (10 and 100 counts per sec.), 1.5 seconds (1000 and 10,000 counts per sec.)

Front panel Zero Suppression control is via a 22 turn screwdriver adjust potentiometer with a 25% of full scale range.

A greater than 28% count rate overrange results in the meter reaching its upper limit for up to 5 seconds, after which the system resets and resamples the input rate.

The Model 2081 offers better than ±0.3% linearity, a rear panel (0 to +5 volts) recorder output, and a 2% precision front panel edge meter with 2.75 inch (7 cm) anti-parallax scale.

Specifications

INPUTS

INPUT - Positive or Negative, Internal Jumper selectable. Factory set to Positive

POS - Positive Logic Pulses, Front and Rear Panel BNC

HIGH	+2.5 to +5.0V	Source:	0.2mA
LOW	0 to +0.5V	Sink:	2.4mA

Minimum Width - 20ns

Maximum Rise and Fall Time - 1μs

Minimum Pulse Pair Resolution - 40ns

NEG - Negative (Positive and Negative Inputs are mutually exclusive)

Logic 1	– 0.6 to – 2.0 Volt
Logic 0	0 to – 0.05 Volts

Imput Impedance - 50 ohms DC coupled

Minimum Pulse Width - 20ns

Minimum Pulse Pair Resolution - 40ns

OUTPUTS

READOUT - Front panel meter with 2-3/4 inch (7 cm) scale length, seven full scale ranges from 10 to 10,000,000 counts per second plus an extra range to 25,000,000 counts per second

RECORDER - 0 to +5 volts full scale, 1000 ohm output impedance, rear panel BNC

CONTROLS

RANGE - Front panel rotary switch selects 10^1, 10^2, 10^3, 10^4, 10^5, 10^6, 10^7, and 2.5×10^7 counts per second

ZERO SUPPRESSION - 25% of the meter scale may be suppressed by this front panel, 22 turn, screwdriver adjust control

Specifications(continued)

PERFORMANCE

RANGE - 7 full scale range steps from 10 to 10,000,000 counts per second plus an eighth range extending the input range to 25,000,000 counts per second

TIME CONSTANTS - Selected by range switch and provides 3 seconds for 10 and 100 count ranges and 1.5 seconds for 1000 and 10,000 count ranges

OVERRANGE - 28% or greater Overrange causes the meter to go to full scale for up to 5 seconds, after which sampling of Input begins again

AVERAGING PERIOD - 1 to 10 counts per second: 10 seconds
All other ranges: 1 second

COUNT RESOLUTION - 1 part in 128

NON-LINEARITY - ⩽±0.3% of selected full scale range

READOUT ACCURACY - Meter ±2%, Recorder ±2%

TEMPERATURE DRIFT - ⩽0.02%/°C

OPERATING TEMPERATURE - 0 to 45°C

PULSE PAIR RESOLUTION - 40ns for 10^7 and 2.5×10^7 ranges, 300ns for remaining ranges

CONNECTORS

INPUT - Front and rear panel BNC type

RECORDER OUT - Rear panel BNC type

POWER REQUIREMENT

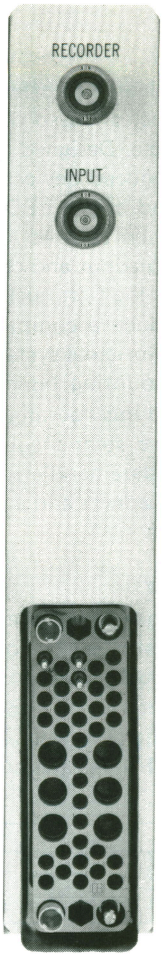
+24V	60mA	+12V	150mA
- 24V	0mA	- 12V	15mA

PHYSICAL

SIZE - Single width NIM (1.35 x 8.71 inches) (3.42 cm x 22.13 cm) per TID 20893 (rev.)

NET WEIGHT - 2.2 lbs. (1.0 kg)

SHIPPING WEIGHT - 7.2 lbs. (3.24 kg)



Canberra Industries is pleased to offer the newest and most comprehensive nuclear-based data acquisition system presently available. Designed to capitalize on the most recently introduced devices, such as fast semiconductor chips and bright LED displays, the Canberra System has been tailored to operate with the most sophisticated readout and computer devices. Canberra Industries was the first nuclear instrument manufacturer to introduce a comprehensive data acquisition system. The original system was designed around basic nuclear counting building blocks – scalers and timers – and incorporated "daisy chain" readout capability. The system encompassed a variety of associated data handlers including buffers, multiplexers, scanners and a wide assortment of readout devices.

SYSTEM PHILOSOPHY

The simplest system is one which presents the data in a fully parallel form; that is, all bits of all characters are available simultaneously. Since most scalers consist of 6-digit BCD counters, it is quite easy to present the data as 24 lines (6 digits X 4 bits/digit) on an output connector. Figure 1 illustrates such a system.

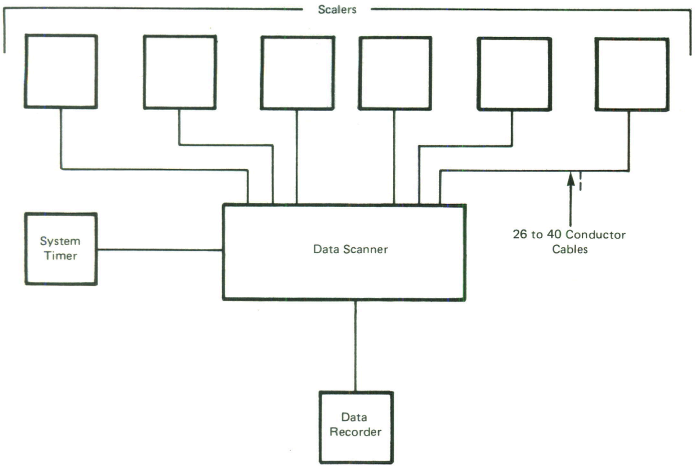


Figure 1. Parallel Data System

While a system of this type operates quite well, there are two major disadvantages, both of which add greatly to the system cost:

1. Large (26 - 40 conductor), expensive cables are required to connect the scalers into the system.

2. A complex system multiplexer is required to interface the system to a readout device. This increases the cost and limits the performance, since a multiplexer cannot have an unlimited number of inputs.

Both of the previous mentioned disadvantages can be overcome by using a character-serial, bit-parallel bus to connect the scalers to the readout scanner. Figure 2 illustrates a typical system of this type. Note that the number of conductors required has been reduced from 24 to 4, reducing the cabling cost significantly.

The system shown in Figure 2 further reduces the cost by not requiring a complex multiplexer. To become fully operational, however, the system must be refined to include signals for controlling the data transfer, starting and stopping the scalers, etc.

It is quite simple to start, stop, or reset the scalers. Three additional lines are added to the bus, and by pulsing the appropriate line the system MASTER can control the data acquisition.

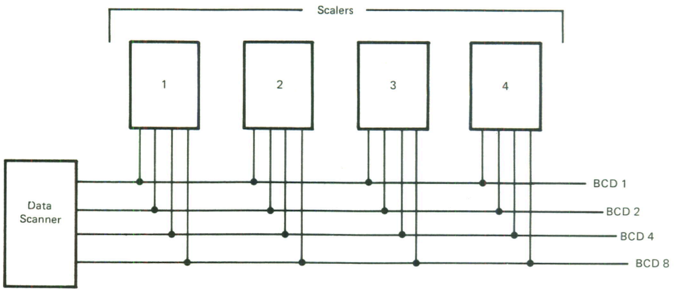


Figure 2. Character Serial, Bit Parallel System

Data transfer can be accomplished by the addition of a single line to the bus. The data scanner provides a pulse train to the line. The first six pulses transfer the data character-by-character, from scaler 1 to the bus; the following six pulses transfer scaler 2, and so forth. This pulse train method of data transfer leaves only one problem yet to be solved – how does a given scaler recognize when it is its turn to transfer data?

SYSTEM PHILOSOPHY

Figures 3 and 4 illustrate the solution to this one last problem. Instead of connecting all of the scalers to the bus in parallel, the bus enters scaler 1, leaves 1 and enters 2, etc. This is known as a "daisy chain". By this method, each scaler processes the pulse train, transfers its data and then passes the pulse train on to the next scaler. In this way the "which pulses are mine?" problem is solved: each scaler processes the first six pulses it sees. This method, used in all Canberra data acquisition systems, provides maximum flexibility at minimum cost.

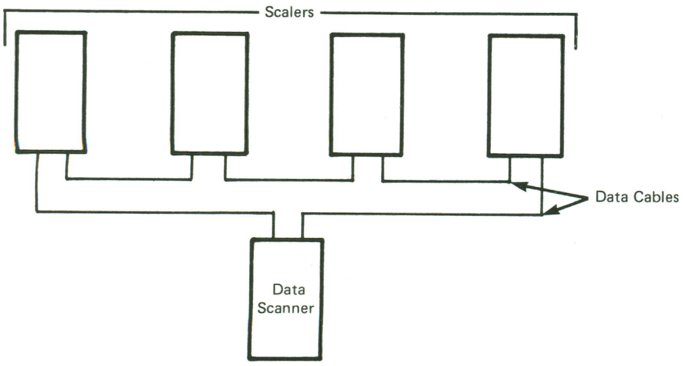


Figure 3. "Daisy Chain" Cable Hookup

DATA INPUT MODULES

Experience has shown that a large number of different counting units are needed to insure an optimized solution to a variety of data acquisition requirements.

The various types of scalers and timers are described in general terms in this section and are illustrated with pictures and descriptions of the more popular Canberra modules.

SCALERS

A scaler is a device that accepts and counts pulses. The Canberra Model 1771 is a typical, and very simple, low-cost scaler. It has a six-decade counter which can accept a 25-30MHz count rate and includes an easy-to-read LED display for visual readout.

The Model 1773 is identical to the 1771 with the addition of the daisy chain readout circuitry. In a system the 1773 would be a "slave" instrument; start, stop and reset would be controlled by the system "master".

The Model 1774 is a dual scaler combining two pulse counting circuits in a single module. In addition to providing a visual LED display for both scalers, both scalers can be connected to the Canberra "daisy chain" for data printout.

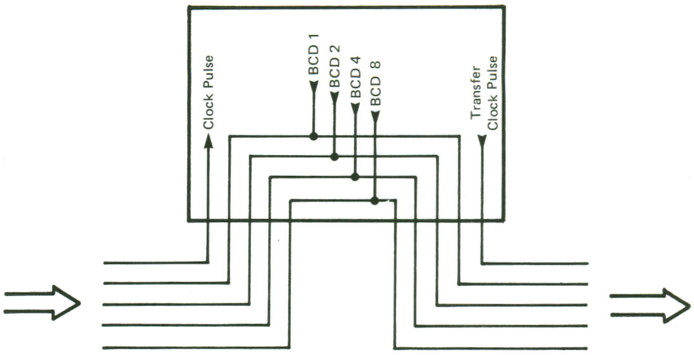


Figure 4. "Daisy Chain" Internal Scaler Logic

A third type of scaler is the blind scaler, such as Canberra's Model 1476A; it has no visual display. It is normally found in large, automatic data acquisition systems where simultaneous display of all counting channels is not required and where it is essential to minimize cost and/or space. At the press of a button any 1476A Scaler in the System can be displayed on the 1790C Universal Scaler/timer.

The count capacity of any Canberra scaler can be increased by the inclusion of a prescaler circuit. This is, in effect, a decade, built into the scaler. The addition of the seventh decade provides a X10 multiplication of the displayed data, eliminating display of the least significant digit.

TIMERS

In most cases, the desired result from a nuclear data acquisition system is a value expressed in counts per unit time; an accurate time base is required to do this. This time base is most often incorporated into a scaling or counting module (see counters/timers) but is available as a separate unit. The Canberra Model 1770 is a typical timer. It includes a five-decade scaler to count clock pulses, and a 0.1 second or 0.01 minute internal clock pulse generator.

All Canberra timers are presettable; that is, they can be told to count time until x seconds have elapsed. At the end of the elapsed time, a pulse is used to stop the scalers in the system from accepting further data. If the timer is used as a system master, the timer will also initiate automatic readout of data.

COUNTER-TIMERS

A counter/timer is a very simple counting system and is commonly included in even the most complex data acquisition system. It normally serves as the system master controller and consists of one or more scalers plus a timer in a single unit. In addition to having the capability of presetting time, some counter/timers will have a preset count feature. This enables the system to be stopped when the preset count or a preset time condition is reached.

Canberra offers a wide variety of counter-timer instruments:

1772 COUNTER/TIMER
- one six-decade scaler
- line frequency preset timer
- 0.1sec or 0.01min time base

1775 NUCLEAR COUNTER
- one six-decade scaler
- line frequency preset timer
- preset on time or count
- precision discriminator
- daisy chain output

1776 DUAL COUNTER/TIMER
- two six-decade scalers
- crystal time base; allows one scaler to be used as timer
- dual presets on time or counts
- dual discriminators
- daisy chain output

1790C UNIVERSAL COUNTER/TIMER
- three six-decade scalers
- crystal time base and one scaler serves as timer
- dual presets on time and counts
- daisy chain output
- master display unit for blind scalers

READ OUT MODULES

In most data acquisition systems, some form of automatic readout is desired. This section describes the various modules associated with the readout portion of a data acquisition system.

SYSTEM BUFFER

A buffer is a data holding device which is commonly used where system dead time is to be minimized. It eliminates the need for the scalers to transfer data directly to the readout device — a process often requiring several seconds. When a buffer is used, data from the scalers and timers are rapidly transferred to the system Buffer Model 1784. The data acquisition system is then free to begin a new cycle while the buffer transfers data to the output device via a data scanner.

SCANNERS

Every system with automatic readout requires an output scanner or interface device. The scanner contains the pulse train generator and command logic necessary to transfer the data from the scalers to the "daisy chain" bus. It also includes any control and data conversion logic required to interface to the output device. In some cases, such as with the Canberra Model 2089 Scanner/Printer, the readout device is built into the scanner.

For many years the most common form of readout device in the laboratory was a technician or scientist with pencil and paper. For data acquisition systems, however, this is normally not adequate; a readout scanner and appropriate readout device are required. The larger and more complex the data acquisition system the more advantageous it is to have automatic readout. The following table lists some of the devices available from Canberra:

SCANNER	DEVICE	TIME TO PRINT ONE SCALER
1487	Paper Tape Punch	approx 50ms
1488	Teletype	approx 600ms
2089	Integral Printer	approx 700ms
1788	EIA Compatible Devices	approx 25ms@2400 baud

EIA COMPATIBLE INTERFACE

For the ultimate in automatic data acquisition, the nuclear counting system should send its data directly to a computer for processing. This capability can be added to any printing Canberra data acquisition system with the Model 1788 Communications Interface. The Model 1788 is a combination readout scanner/EIA RS232C Interface. The EIA RS232C output of the Model 1788 allows the user to directly connect a NIM data acquisition system to any computer with an EIA I/O port, as shown in Figure 5. This capability allows on-line data acquisition with virtually any computer available today.

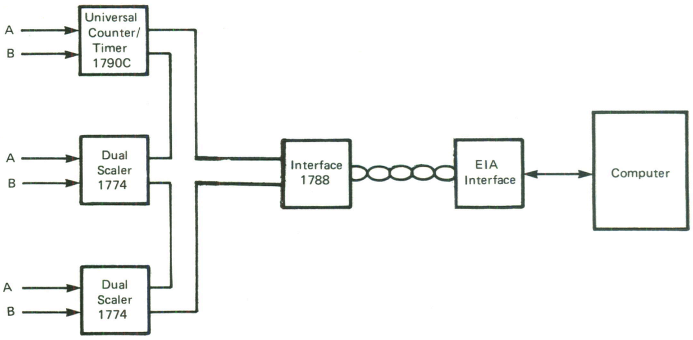


Figure 5. Computer Readout of Daisy Chain

TAG WORD INPUT

In addition to presenting accumulated raw data to a readout device, it is often desirable to include information about where the data being acquired came from, sample identification, operator identification number, etc. The Model 1482 Data Input module has been designed specifically to provide this capability. It is available with up to four sets of six-digit thumbwheel switches for use in manual data entry; multiple Model 1482s can be used if required. Each six-digit set is read out through the daisy chain exactly as if it were a scaler or timer in the counting system.

MULTIPLEXED SYSTEMS

Multiple scaler systems with different presets that will read out at separate times can share the same output device by means of the Model 1485 System Multiplexer. Each scaler subsystem should have a Model 1482 Tagword Input to identify its data in the output sequence.

PARALLEL-TO-SERIAL CONVERTER

The Model 1483 Parallel-to-Serial Converter is useful for connecting devices with up to 6 BCD characters of parallel output into the Canberra "daisy chain" bus for inclusion in the readout sequence. Non-Canberra manufactured items can be interfaced in this fashion.

CHRONOMETER

The Canberra Chronometer, Model 1795, is a precision time recording instrument. This device can be used to record the time of the year of the data collection, in days, hours, minutes and seconds. In addition, it provides two digital thumbwheel switches for entering a fixed tagword, and a BNC signal input for setting a system flag bit. There is an alternate mode of operation that allows the 3 digit day counter to be used as an auto-incrementing run counter. This is especially useful in sample changer systems where the run counter would indicate sample number.

The data from the Chronometer can be read out on any Canberra Nuclear Data System. Since the unit is fully buffered and synchronized there is no possibility of a transition error during printout of the data.

TIMERS/SCALERS SELECTION CHART

Model	1770	1771	1772	1773	1774	1775	1776	1790C	1476A	1490C
Description	Blind Timer/ Scaler	Scaler	Counter/Timer	Scaler	Dual Scaler	Nuclear Counter (Timer & Scaler)	Dual Counter/ Timer	Universal Counter/ Timer (2 Scalers & 1 Timer)	Blind Scaler	Blind Timer
Prescaler	no	yes	yes	yes	yes	no	yes	yes	no	no
Decades	5	6	6	6	6	6	6	6	6	6
Time Base	.1 sec .01 min		.1 sec .01 min			.01 sec .01 min	.01 sec .01 min	.1 sec .1 min		1 sec
Count Rate Neg		25MHz 30 typ	25MHz 30 typ	25MHz 30 typ	25MHz 30 typ	25MHz 30 typ	25MHz 30 typ	20MHz 25 typ	12MHz 20 typ	
Pos		25MHz 30 typ	25MHz 30 typ	25MHz 30 typ	25MHz 30 typ	25MHz 30 typ	25MHz 30 typ	20MHz 25 typ	12MHz 20 typ	
Display & Size		1, large LED	1, large LED	1, large LED	2, large LED	1, large LED	2, large LED	1, large LED		
Blind Scaler Display		no	no	no	no	no	no	yes		
Preset	time or count	time	no or counts	time	no	no or counts	time or counts	time and/or counts	no	time
Printout	no	no	no	Scaler	2 Scalers	Timer or Scaler	Timer and Scaler	Timer and 2 Scalers	Scaler	Timer
Disc.	no	front panel	front panel	front panel	front panel	10-turn pot.	yes internal	yes internal	front panel	
Overflow	no	yes	yes	yes	yes	yes	yes	no	yes	no
Gate In	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Gate Out	yes	no	yes	no	no	yes	yes	yes	no	yes
NIM Widths	1	2	2	2	2	2	2	3	1	1

Model 1476A
Blind Scaler

Features

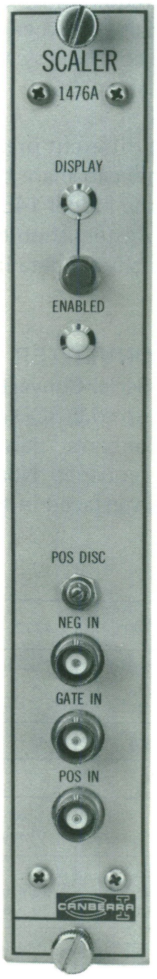
- Economical printing scaler
- Remote visual readout capability
- Front panel variable discriminator

Description

The Canberra Model 1476A Blind Scaler is a 12MHz (20MHz, typical) printing scaler. It functions as a system slave, counting at a 12MHz rate when enabled by a Model 1790C Universal counter which acts as a System Master.

The Model 1476A provides a serial BCD readout capability compatible with Teletype, punched paper tape, or magnetic tape data acquisition equipment when controlled by the Model 1487, 1488, or 1788 Data Scanner modules respectively.

The Model 1476A features front panel discriminator and remote display controls, as well as a fast electronic gating capability, for maximum operating flexibility. The electronic gating capability permits simple coincidence experiments without the need for additional coincidence modules, or the capability of being externally inhibited (along with other scalers or timers in the system) by external command. The remote display pushbutton permits displaying the accumulated count on an associated Model 1790C Universal Counter.



Specifications

INPUTS

POSITIVE INPUT - +0.5 to 10 volts (50 volts maximum); any rise time, minimum width 35 nanoseconds (duty cycle not to exceed 50%); input impedance, 1000 ohms, DC coupled, front panel BNC connector

NEGATIVE INPUT - - 0.2 to - 3 volts (- 20 volts maximum) any rise time, minimum width 5nsec., input impedance 50 ohms, DC coupled, front panel BNC connector

GATE INPUT - +3 to +10 volt DC level or pulse (or open circuit) enables accumulation; less than 1.0 volt DC level or pulse (or short circuit) inhibits accumulation; current sinking 4mA, DC coupled; front panel BNC connector

CONTROL INPUT - rear panel Amphenol 17-20150 15-pin connector accepts START, STOP, RESET, and PRINT commands: 5-volt negative-going pulses from +5 volt level; rise time 500 nanoseconds maximum; width 1.0 microsecond minimum; HOLD command: DC level change from +5 volts to 0.5 volts maximum during printout; DISPLAY CLOCK command: 1kHz, 0 to +5 volts, with a synchronization excursion to +12 volts every seventh pulse; 1.0 microsecond minimum pulse width.

OUTPUTS

CONTROL OUTPUT - rear panel Amphenol 17-10150, 15-pin connector provides DATA OUTPUT: decimal digit serial, 1-2-4-8 BCD; logic 1 = +4 volts; logic 0 = 0 volts; DISPLAY OUTPUT: decimal digit serial 1-2-4-8-BCD; logic 1 = 0 volts logic 0 = +4 volts; PRINT command; eighth and successive Print input pulses are routed to the OUTPUT connector

OVERFLOW (Optional) - +5 volt pulses at reset of sixth decade; rise time less than 50 nanoseconds; width 4 microseconds minimum; output impedance 50 ohms; DC coupled; rear panel BNC connector.

CONTROLS

DISC - front panel screwdriver adjust control to inhibit counting of input pulses below selected level from 0.5 to 10 volts positive; ten-turn potentiometer control optional

DISPLAY - front panel pushbutton to display accumulated count on the Model 1790C Universal Counter.

PERFORMANCE

CAPACITY - six decades, allowing count of 10^6-1

SPEED - 12 MHz (20 MHz typical)

TEMPERATURE - 0 to 50°C

CONNECTORS

POS IN, NEG IN, GATE IN - front, BNC UG-1094/U

CONTROL INPUT - rear, Amphenol 17-20150

CONTROL OUTPUT - rear, Amphenol 17-10150

OVERFLOW (Optional) - rear, BNC UG-1094/U

POWER

+24V	— 0mA	+12V	— 45mA
- 24V	— 0mA	- 12V	— 15mA
115VAC	— 85mA		

PHYSICAL

SIZE - standard single width module (1.35 inches wide) (3.43 cm) per TID-20893

NET WEIGHT - 2.4 lbs. (1.08 kgs.)

SHIPPING WEIGHT - 7.4 lbs. (3.33 kgs.)

Model 1482-1,-4
Data Input

Features

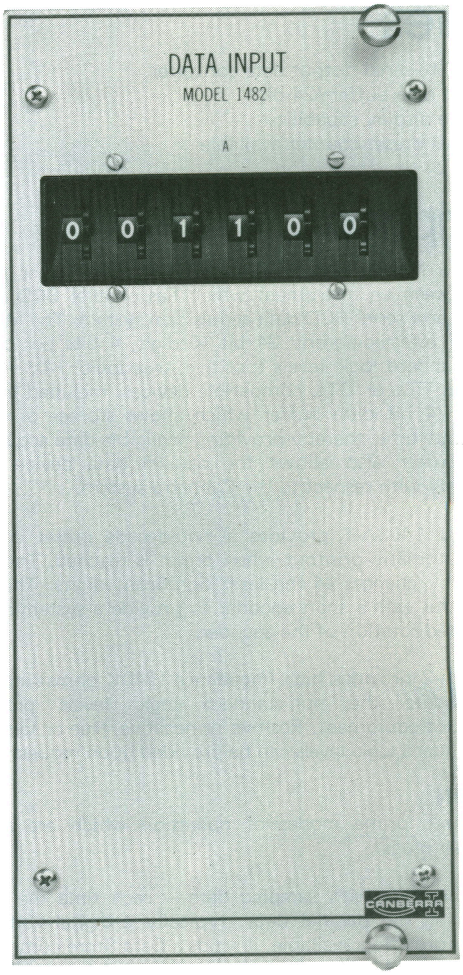
- 6 to 24 digit tagword(s) capability
- Each 6 digit bank may be recorded independently
- Serial BCD format
- Compatible with all Canberra scanners

Description

The Model 1482 Series of Data Input modules has been designed to permit the experimenter to tag or code the output record of data acquisition systems by selecting, via decimal digital thumbwheels, from 6 to 24 digits of information to be recorded in serial BCD format *exactly as are the scalers and timers in the data recording system* with which the module is used.

The Model 1482-1 permits the selection of six digits of coding or tagging information via a six-digit bank of digital decimal (0-9) thumbwheels. The six digits thus selected will be scanned by the Model 1487, or 1488 Print Control (used for magnetic tape, punched paper tape, or Teletype recording respectively) and recorded in the same formats as are the scalers and timers whose accumulated information is being recorded.

The Model 1482-4 offers twenty-four digits of selectable data. Each six-digit bank may be inserted independently anywhere throughout the printout sequence, or independently in different data recording systems.



Specifications

INPUTS

DATA SELECTION - six digits via digital thumbwheels (Model 1482-1); twenty-four digits via thumbwheels for the Model 1482-4.

CONTROL INPUT - 15-pin connectors accept PRINT and PRINT RESET commands; 5 volt negative-going pulses from +5 volt level, maximum rise time 500 nanoseconds, minimum width 75 nanoseconds; DC coupled; rear panel Amphenol 17-20150 connector for each bank of six digits.

OUTPUTS

CONTROL OUTPUT - 15-pin connectors provide SERIAL BCD, and PRINT commands; 5 volt negative-going pulses from +5 volt level, rise time less than 50 nanoseconds, PRINT RESET command; DC level change from +5 volts to +0.5 volts maximum during printout; DC coupled; rear panel Amphenol 17-10150 connector for each bank of six digits.

CONTROLS

DATA INPUT - front panel data selection controls, six-digit banks of thumbwheel decimal switches; 1482-1 has one bank, 1482-4 has four banks. All banks are fully independent and may be inserted independently at different points in the printing sequence (e.g., one bank before each of four scalers, 1482-4).

PERFORMANCE

TEMPERATURE - 0 to 50°C.

CONNECTORS

CONTROL INPUT - rear panel Amphenol 17-20150, one per each six-digit bank.

CONTROL OUTPUT - rear panel Amphenol 17-10150, one per each six-digit bank.

POWER

+24V — 0mA +12V — 24mA
-24V — 0mA -12V — 0mA
115VAC — 15mA per 6 digits

PHYSICAL

SIZE - standard triple-width module (4.05 inches wide) (10.29 cm) per TID-20893.

NET WEIGHT - 3.4 lbs. - 4.8 lbs. (1.5 kgs - 2.2 kgs).

SHIPPING WEIGHT - 8.4 lbs. - 9.8 lbs. (3.8 kgs. - 4.4 kgs).

ACCESSORIES

One Canberra Model C-1404 Data/Control Cable 2 ft. in length is supplied for each six-digit bank for connection to other Canberra data acquisition series modules.

Model 1483A
Parallel-to-Serial Converter

Features

- Parallel-to-serial output data converter
- Built-in data buffer (24 bit)
- Remote display capability
- Optional preset counter available
- Master or slave operation

Description

The Canberra Model 1483A Parallel-to-Serial Converter provides an interface between an instrument which has parallel BCD data output and the Canberra serial BCD data acquisition system. The Model 1483A is capable of interfacing any 24 bit (6 digit, 4 bits per digit) device which has standard logic levels (positive, true logic, +4V = "1", OV = "0"), such as TTL or DTL compatible devices. Included in the Model 1483A is a 24 bit data buffer which allows storage of information during printout time, thereby providing negligible data acquisition dead time. The buffer also allows the parallel data device to operate asynchronously with respect to the Canberra system.

Option Model 1483A-1 provides a two-decade preset counter that enables an automatic printout when preset is reached. The counter is incremented by changes of the least significant digits. This feature is especially useful with a shaft encoder to provide a system printout for each preselected rotation of the encoder.

Option 1483A-2 provides high impedance (240K ohms) input circuits to accommodate the non-standard logic levels provided on Hewlett-Packard equipment. Positive or negative, true or false logic and other non-standard logic levels can be provided upon request.

OPERATION

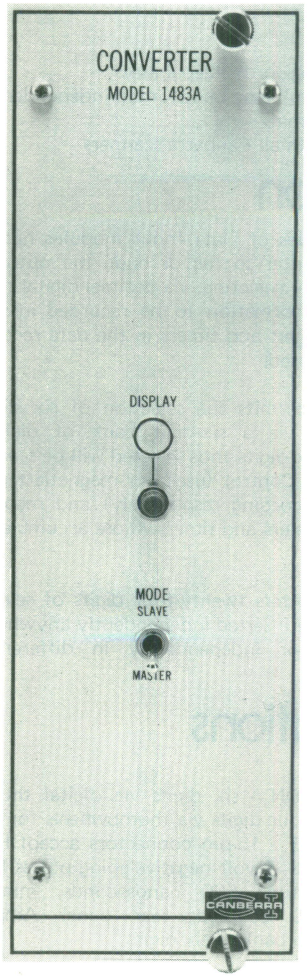
There are three prime modes of operation which are selected by internal jumper plugs:

1. Asynchronous with sampled data — each time the instrument producing the parallel data (typically a digital voltmeter) has new information available, it sends a Data Store command to the Model 1483A. At this time, the internal storage buffers are updated with new information. This updating process continues until a printout command is initiated by the Canberra system master. The buffers then hold the last data received until the end of printout.

2. Asynchronous with continuous data — the unit producing the parallel data (typically a shaft encoder) has continuously changing data. This data may be displayed directly on the Model 1790C Universal Counter/Timer display unit until a printout command is initiated. At this time the data are sampled and held in the buffer until the end of printout.

3. Synchronous — the Model 1483A routes Start and Stop commands from the Canberra data system to the parallel unit (typically a parallel output scaler). Once the printout is initiated the buffers sample and hold the data until the end of printout.

In addition to the above modes of operation, the Model 1483A can operate as a Master or Slave unit. In Master mode, the stop printout cycle is initiated by the Model 1483A from the Data Store command or, with option 1483A-1, when the preset is reached. In the Slave mode the stop transfer data printout cycle is initiated in the Canberra data system.



Specifications

INPUTS

INTERFACE CONNECTOR - Data — six decimal digits on 24 parallel (1-2-4-8) binary coded decimal lines; standard logic levels; positive true logic (TTL compatible), 4±1.5V = logical "1", 0±0.4V = logical "0"; optional logic (Model 1483A-2) (Hewlett-Packard compatible), -8V = logical "1", -2V = logical "0": Data Store Command — pulse of standard logic levels sent by the parallel data device to strobe information into 24 bit storage buffer; minimum pulse width = 1.0μsec.

CONTROL INPUT CONNECTOR - accepts START and PRINT commands from data acquisition system; signals are 5 volt negative-going pulses starting from +5.0 volt DC level; also accepts HOLD command, a DC level change from +5.0 volts to 0.35 volts during printout, and DISPLAY, a 1kHz pulse train, 0 to +5.0 volts, with synchronization excursion to +12 volts every seventh pulse.

EXTERNAL RESET - BNC connector accepts a negative-going pulse from +5.0 volt level to reset the preset counter to zero (Model 1483A-1 only)

Specifications(continued)

OUTPUTS

INTERFACE CONNECTOR - provides START and STOP signals; 5.0 volt negative-going pulses from +5.0 volt level; inverse logic available upon request; rise time less than 500 nanoseconds, width greater than 2 microseconds.

CONTROL OUTPUT CONNECTOR - provides Data Output, decimal digit serial 1-2-4-8 BCD signal, logical 1 = +4 volts, logical 0 = 0 volts; also provides complementary 1-2-4-8 BCD signals with logical 1 = 0 volt and logical 0 = +4 volts; the eighth and successive PRINT commands are routed out via the CONTROL OUTPUT connector; when the unit is used in the MASTER mode a STOP signal is provided to the daisy chain loop through the control output connector.

PERFORMANCE

CAPACITY - accepts six digits of parallel BCD.
PRESET (Model 1483A-1) - 0-99 steps.
TEMPERATURE - 0 to 50°C.
DATA TRANSFER TIME - less than 10 microseconds.

CONTROLS

DISPLAY PUSHBUTTON - front panel pushbutton to display stored data on Model 1790C Universal Counter/Timer display.

MASTER/SLAVE - front panel toggle switch to enable or inhibit the effect of a stop signal generated in the Model 1483A. In the MASTER mode, when preset is reached (Model 1483A-1) or a Data Store command is received (Model 1483A) a stop pulse will be generated and sent to the main loop which causes all units in the daisy chain to stop and result in a printout of the system; in SLAVE mode, the Model 1483A will respond to a system STOP by strobing data into the buffers and holding that data until the end of printout.

INDICATORS

DISPLAY - front panel indicator to indicate contents of buffer are being displayed by a remote display device.

CONNECTORS

INTERFACE - rear panel Amphenol 17-20500.
CONTROL IN - rear panel Amphenol 17-10150.
CONTROL OUT - rear panel Amphenol 17-20150.
EXT RESET (1483A-1) - rear panel BNC UG-1094/U.

POWER

+12V	—	85mA	+12V	—	0mA
-12V	—	10mA	-24V	—	100mA
115AC	—	60mA			

PHYSICAL

SIZE - standard double-width NIM module (2.70 x 8.71 inches) per TID-20893 (rev.)
NET WEIGHT - 3 lbs. (1.35 kgs.)
SHIPPING WEIGHT - 8 lbs. (3.6 kgs.)

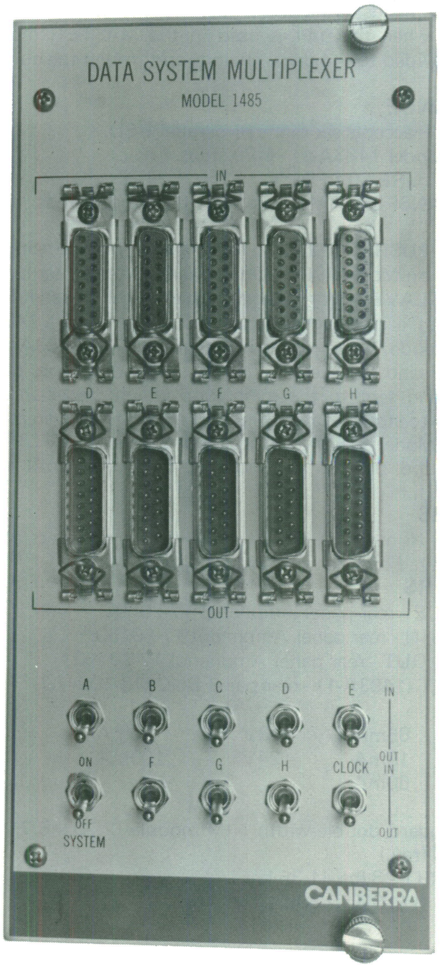
Model 1485
Data System Multiplexer

Description

The Canberra Model 1485 Data System Multiplexer permits the data accumulated in up to eight independent, asynchronously operating data acquisition systems to be printed out through a single output recorder, using a single data scanner. Used in this manner, the Model 1485 is compatible with the Model 1487 Paper Tape Scanner, the Model 1488 Teletype Scanner, and the Model 2089 Serial Scanner Printer.

The Model 1485 has a ninth pair of input/output connectors, to permit a Model 1795 Chronometer to be inserted into the data record of *each* of the independent data systems, printing through the common output device.

The Data Multiplexer follows a first-come, first-served order. Data recording of one system does not affect the other systems in any way. The use of a Model 1482 Data Input module is almost always required, to identify the various systems being recorded. Any system connected to the Model 1485 may be disconnected by switching the associated front panel toggle switch to the OUT position.



Specifications

INPUTS

CONTROL INPUTS - ten 15-pin connectors, eight available for up to eight data systems which may be multiplexed, one for the Chronometer (if any) and one for the Data Scanner; each accepts 1-2-4-8 BCD data in character serial bit parallel format; data format: logical 1 = +4 volts, logical 0 = 0 volts; each connector also accepts the individual data system STOP commands; commands are 5 volt negative-going pulses from +5 volt level; width greater than 75 nanoseconds; DC coupled; Amphenol #17-10150 connectors, five front panel, five rear panel.

OUTPUTS

CONTROL OUTPUTS - ten 15-pin connectors, eight available for up to eight data systems which may be multiplexed, one for the Chronometer (if any) and one for the Data Scanner; each provides system STOP, PRINT, HOLD, RESET, START commands to the units being printed; commands are 5 volt negative-going pulses from +5 volt level; maximum rise time 500 nanoseconds, width greater than 75 nanoseconds; DC coupled; Amphenol #17-20150 connectors, five front panel, five rear panel.

CONTROLS

SYSTEM IN/OUT - nine front panel toggle switches, one for each system connected (A-H) and one for the CLOCK; IN position connects the data acquisition system indicated to the multiplexer/scanner/recorder; OUT position removes the indicated system from the output channel entirely.

SYSTEM ON/OFF - front panel toggle switch; OFF position disconnects *all* connected data acquisition systems, inhibiting any printout; ON position allows normal system operation.

PERFORMANCE

TEMPERATURE OPERATING RANGE - 0 - 50°C ambient.

CONNECTORS

CONTROL INPUTS - ten Amphenol #17-10150, five front panel, five rear panel.

CONTROL OUTPUTS - ten Amphenol # 17-20150, five front panel, five rear panel.

POWER REQUIREMENTS

+24V — 0mA   +12V — 210mA
- 24V — 0mA   - 12V — 110mA

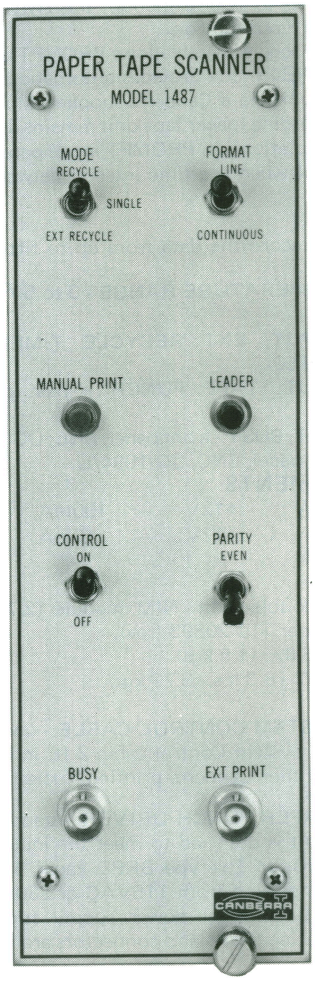
PHYSICAL

SIZE - standard triple-width NIM module (4.05 x 8.71 inches) per TID-20893 (rev.)

NET WEIGHT - 4.4 lbs. (2.0 kgs).

SHIPPING WEIGHT - 9.4 lbs. (4.23 kgs).

Model 1487 Paper Tape Scanner



Features

- Compatible with BRPE and Facit punches
- External control of punch and integral sequences
- Standard output for ASR33TTY

Description

The Canberra Model 1487 Paper Tape Scanner permits the data stored in up to fifty compatible scalers and timers to be recorded in eight-level ASCII code on punched paper tape.

The Model 1487 has been designed for easy cable-connection with any of the units in a Canberra Nuclear Data Acquisition System, and provision has been made for all control and interfacing required to allow direct plug-in cable connection of the Facit 4070 or, the Teletype BRPE punch.

When interfaced to the tape punch via the Canberra Model 1487D Punch Driver, the Model 1487 provides automatic starting and stopping of the tape punch. This feature eliminates the necessity of having the punch idle, and can significantly increase its life. This unit may be purchased from Canberra Industries.

The Paper Tape Scanner may also serve as System Control, allowing single or recycle system operation, with provision for external timing of the interval between system data accumulation cycles.

Specifications

INPUTS

CONTROL INPUT - 15-pin connector accepts PRINT (completed) command from the last unit to be recorded, and character serial BCD information from each successive unit; Command Signal: 5-volt negative-going pulse from a +5 volt level, maximum rise time 500 nanoseconds, minimum width 1 microsecond; Data Signals: positive logic where logic 1 = +4 volts, and logical 0 ⩽+0.2 volts; DC coupled; rear panel Amphenol 17-10150 connector.

EXT RECYCLE TIMER - accepts pulse which causes counting system to recycle, and provides pulse to start external timer; 5 volt negative-going pulse from a +5 volt level, maximum rise time 500 nanoseconds, minimum width 1 microsecond, DC coupled; rear panel Amphenol 17-20150 connector.

EXTernal PRINT - accepts pulse which causes entire system to stop, and data recording to begin; +4 to +10 volt pulse, minimum width, 1 microsecond, maximum rise time 500 nanoseconds; DC coupled; front panel BNC connector.

SYNC INPUT - accepts synchronizing signals from tape punch if tape punch speed is independent (such as is the Teletype BRPE), pulse greater than 6 volt amplitude, rise time comparable to the output of the BRPE, minimum duration 10 microseconds; DC coupled; rear panel BNC connector.

OUTPUTS

CONTROL OUTPUT - provides PRINT, HOLD, RESET, and START commands; 5 volt negative-going pulse from a +5 volt level, rise time less than 500 nanoseconds, width greater than 3 microseconds; HOLD command: DC level change from +5 volts to +0.35 volts maximum during printout; DC coupled; rear panel Amphenol 17-20150 connector.

TAPE PUNCH (Data Output) - provides data and solenoid driver signals (through the Canberra Model 1487D Paper Tape Punch Driver) to the punch unit in the data format required. Negative logic TTL levels are output from the 1487. The drive and timing can be factory adjusted in the 1487D.

BUSY - provides a +5VDC level output during the time the Model 1487 is data recording and ≈+ 0.3VDC level while the system is accumulating (when not busy); current sinks 25mA in the low (+ 0.3V) state; front panel BNC connector.

CONTROLS

MODE - front panel 3-position toggle switch selects SINGLE or RECYCLE data accumulation by the system, or EXT RECYCLE mode, timed by an auxiliary timer (such as the Canberra Model 1490C).

CONTROL - front panel toggle switch to enable (ON) or inhibit (OFF) data recording of accumulated system data.

PARITY - front panel toggle switch to select EVEN or ODD parity bit in punched data record.

FORMAT - front panel toggle switch to select LINE or CONTINUOUS data print format; LINE selection causes each new data cycle record of one or more scalers, timers, or other input devices to begin on a new line when the punched tape is read out on a line printer such as the Teletype Model 33ASR; CONTINUOUS selection causes each record to begin where the last record ended, with line feed and carriage return punch signals occurring after each tenth six-digit data field.

Specifications(continued)

MANUAL PRINT - front panel pushbutton which causes the entire system to stop accumulation and data recording to begin.

LEADER PUSHBUTTON - provides fully punched or unpunched tape to be used as leader (fully punched or unpunched tape selectable via an internal jumper); leader continues for as long as the pushbutton is depressed.

LEADER - rear panel toggle switch to ENABLE or INHIBIT automatic punchout of leader between data fields (length of leader provided when this control is in the ENABLE position is internally adjustable from two to twelve inches); this switch does not affect front panel LEADER pushbutton.

PRINT - rear panel toggle switch allows PROMPT or DELAYED data recording; DELAYED mode provides automatic remote starting of the paper punch unit via a Canberra-supplied Model 1487D Punch Driver for data recording (paper tape unit remains de-energized during system data accumulation); in PROMPT mode paper tape unit is idle all the time, useful when the time interval between data recording cycles is short.

PERFORMANCE

CAPACITY - will record the data from up to fifty compatible data accumulation units.

OPERATING TEMPERATURE RANGE - 0 to 50°C ambient.

CONNECTORS

CONTROL OUTPUT, EXT RECYCLE TIMER - rear panel, Amphenol #17-20150.

CONTROL INPUT, TAPE PUNCH - rear panel, Amphenol #17-10150.

EXTERNAL PRINT, BUSY - front panel, BNC, UG-1094/U.

SYNC INPUT - rear panel, BNC, UG-1094/U.

POWER REQUIREMENTS

+24V* — 0mA
-24V — 0mA
115VAC — 75mA
+12V — 100mA
-12V — 10mA

PHYSICAL

SIZE - standard double-width NIM module (2.70 x 8.71 inches) (6.85 x 22.13 cm) per TID-20893 (rev).

NET WEIGHT - 3.3 lbs. (1.5 kgs).

SHIPPING WEIGHT - 8.3 lbs. (3.73 kgs).

ACCESSORIES

DATA PRINT/SYSTEM CONTROL CABLE - one Canberra Model C-1404 Data Print System Control cable 2 ft. in length is included for connection to other Canberra printing Nuclear Data Acquisition Series NIM modules.

MODEL 1487D PAPER PUNCH DRIVER - standard 19" EIA rack mounting driver unit is designed to meet the input requirements of either a Facit 4070, or Teletype BRPE Paper Tape Punch; when ordering, specify operation from 115VAC or 230VAC, 50 or 60Hz, and +24V or +48V internal power supply for the paper tape perforator coils; mating cables and connectors are included.

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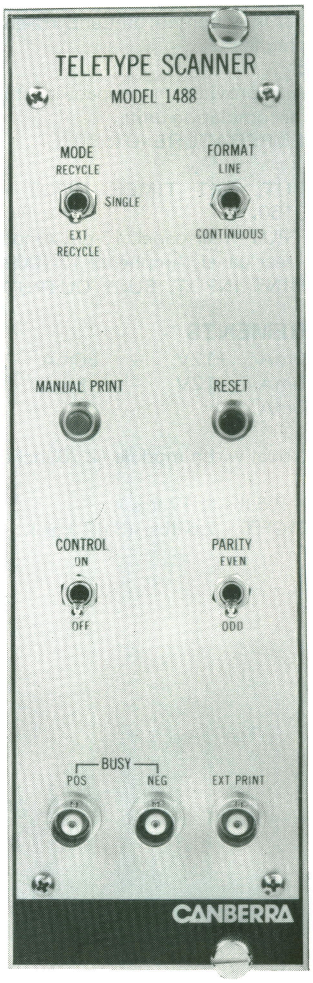
*Draws no current for 1487 but provides relay drive to Punch.

Model 1488 Teletype Scanner



Features

- Automatic control of the teletype machine
- Telephone line transmission capability (two-wire pair)
- Readout control over expandable data acquisition system

Description

The Canberra Model 1488 Teletype Scanner permits the data stored in up to fifty compatible scalers and timers (such as Canberra Models 1773, 1774, 1775, 1790C, 1776) to be recorded on punched paper tape and printed on the Teletype Model ASR33 or ASR35 print/punch console.

The Model 1488 has been designed for easy cable-connection with any unit in a Canberra Nuclear Data System. Provision has been made for all control and interfacing required to allow direct plug-in cable assembly of the Teletype printout system.

The Teletype Scanner features automatic start and stop of the Teletype unit (all Canberra-supplied Teletypes have a remote starting mechanism). This feature reduces Teletype idle time, and can significantly prolong the life of the machine.

The Model 1488 provides two-wire pair control of the Teletype, which permits transmitting the data over telephone lines from remote locations directly into a computer.

When serving as a system master, the Teletype Scanner allows single cycle or recycle system operation, with provision for external timing of the interval between system data accumulation cycles.

Specifications

INPUTS

CONTROL INPUT - 15-pin connector accepts PRINT (completed) Command from the last unit to be recorded, and character serial BCD information from each successive unit; Command Signal: 5 volt negative-going pulse from a +5 volt level, maximum rise time 500 nanoseconds, minimum width 2 microseconds; Data Signals: positive logic levels, where logical 1 = +4 volts, and logical 0 = 0.2 volts; DC coupled; rear panel Amphenol 17-20150 connector.

EXT TIMER INPUT - accepts pulse which causes counting system to recycle and also provides pulse to start an external timer; 5 volt negative-going pulse from a +5 volt level, maximum rise time 500 nanoseconds, minimum width 2 microseconds; DC coupled; rear panel Amphenol 17-20150 connector.

EXTERNAL PRINT - accepts pulse which causes entire data system to stop, and data recording to begin; +4 to +10 volt pulse, 1 microsecond, min. maximum rise time 500 nanoseconds; DC coupled front panel BNC connector.

OUTPUT

CONTROL OUTPUT - 15-pin connector provides PRINT, HOLD, RESET and START command; 5 volt negative-going pulse from a +5 volt level, maximum rise time 500 nanoseconds, minimum width 2 microseconds; HOLD command: DC level change from +5 volts to 0.5 volts maximum during printout; DC coupled; rear panel Amphenol 17-10150 connector.

TTY OUTPUT - provides standard two-wire pair TTY code to the recording unit; signal format is fully compatible with the Teletype unit; also provides voltage to energize the motor control relay; Amphenol 17-10090-1 connector.

BUSY OUTPUTS - provide simultaneous positive and negative DC level logic signals to indicate that the scanner is in the recording stage of a data cycle; POS BUSY provides +5VDC, and NEG BUSY provides +0.3VDC when busy; source impedance, current sink 50mA rise time 50 nanoseconds; two front panel BNC connectors.

CONTROLS

ACCUMULATION MODE - front panel toggle switch to select SINGLE or RECYCLE data accumulation by the counting system, or to select EXTERNAL RECYCLE mode timed by an auxilliary timer (such as the Canberra Model 1490.)

ON/OFF - front panel toggle switch to enable or inhibit data recording after data accumulation.

FORMAT - front panel toggle switch to select LINE or CONTINUOUS data print format; LINE selection causes each new data cycle record of one or more scalers, timers, or other input devices to begin on a new line of the printed output; CONTINUOUS selection causes each record to begin where the last record ended; line feed and carriage return then occurs after each tenth six-digit data field; this format is particularly useful when only one or two units are printed per data recording cycle.

Specifications(continued)

MANUAL PRINT - front panel pushbutton causes entire data system to stop, and data recording to begin.

PARITY - front panel toggle switch selects EVEN or ODD parity bit in punched tape data record.

RESET - front panel pushbutton causes scanner to reset to the initial condition and to provide a carriage return and line feed signal when the next print cycle is initiated.

PRINT PROMPT/DELAYED - rear panel switch allows immediate or delayed presentation of data to the Teletype; DELAYED mode allows time for remote starting Teletype to start and reach operative speed before data is presented; all Canberra-supplied Teletypes have the remote starting feature.

PERFORMANCE

CAPACITY - will provide the capability to record up to fifty compatible data accumulation units.

OPERATING TEMPERATURE - 0 to 50°C.

CONNECTORS

CONTROL INPUT, EXT TIMER INPUT - rear panel; 15-pin Amphenol 17-20150.

CONTROL OUTPUT - rear panel; 15-pin Amphenol 17-10150.

TTY OUTPUT - rear panel, Amphenol 17-10090-1.

EXTERNAL PRINT INPUT, BUSY OUTPUTS - front panel; BNC UG-1094/U.

POWER REQUIREMENTS

+24V	70mA	+12V	80mA
-24V	0mA	-12V	5mA
115VAC	80mA		

PHYSICAL

SIZE - standard dual-width module (2.70 inches wide) (6.85 cm) per TID-20893.

NET WEIGHT - 2.6 lbs (1.17 kgs.).

SHIPPING WEIGHT - 7.6 lbs. (3.42 kgs.).

Model 1490C
Blind Timer

Features

- Printing blind timer
- Serves as system master or slave
- Remote visual readout capability
- Crystal time base

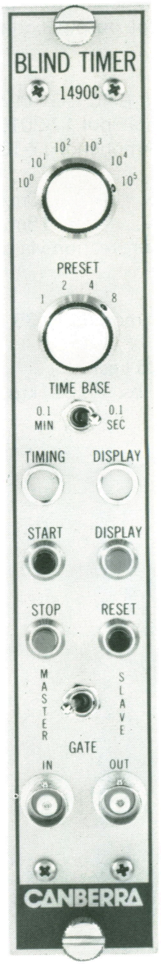
Description

The Canberra Model 1490C Blind Timer is used in the preset time mode to control the duration of nuclear counting experiments, or in the slave mode to indicate the duration of externally controlled experiments. The Model 1490C may thus serve as a preset (Master) or Slave timer operating with an accuracy of 0.002%. When used in the Master mode, the Canberra Blind Timer will control up to 50 Canberra scalers.

The Model 1490C features serial BCD readout capability compatible with the Canberra Daisy Chain for readout options such as TTY, RS232 and all Canberra NIM I/O Devices. Each unit offers front panel preset, *start, stop, reset,* and display mode controls for maximum operating flexibility.

An electronic gating capability permits the Model 1490C to be externally inhibited (as may other scalers or timers in the system) by external command.

Data contained in the Model 1490C Blind Timer may be displayed on a Canberra Model 1790C Universal Counter, using the DISPLAY pushbutton on the front panel of the Blind Timer.



Specifications

INPUTS

GATE INPUT - +3 to +10 volt DC level or pulse (or open circuit) enables accumulation; less than +0.8 volt DC level or pulse (or short circuit) inhibits accumulation; current sink 4mA, DC coupled; front panel BNC connector

CONTROL INPUT - rear panel Amphenol 17-20150 15-pin connector accepts START, STOP, RESET, and PRINT commands; 5 volt negative-going pulses from +5 volt level, rise time 500 nanoseconds maximum, width 1 microsecond minimum. HOLD command: DC level change from 5 volts to 0.5 volt during printout; Also accepts DISPLAY CLOCK command: 1kHz 0.0 to 5 volts, with a synchronization excursion to +12 volts every seventh pulse

OUTPUTS

CONTROL OUTPUT - rear panel Amphenol 17-10150, 15 pin connector provides DATA OUTPUT: decimal digit serial 1-2-4-8 BCD, logic 1 = 4 volts, logic 0 =0 volts, DISPLAY OUT: 1-2-4-8 BCD complement; logic 1 = 0 volts; logic 0 = 4 volts. PRINT command: eighth and successive Print input pulses are routed directly out; all control lines except Print command are wired directly between INPUT-OUTPUT connectors

GATE OUTPUT - +5 volt DC level during accumulation, +0.35 DC level when not accumulating; rise time less than 25 nanoseconds; will current sink 180mA; DC coupled; front panel BNC connector

CONTROLS

PRESET - two front panel rotary switches permitting selection of preset count time at 1, 2, 4, or 8 in the 1st, 2nd, 3rd, 4th, 5th, or 6th decade

START - front panel pushbutton to begin accumulation

STOP - front panel pushbutton to terminate accumulation

RESET - front panel pushbutton to reset all decades to zero

TIME BASE - front panel toggle switch to select 0.1 SEC or 0.1 MIN time base

MASTER/SLAVE - front panel toggle switch to enable preset, controlling all other scalers or timers in counting system, or to disable preset so that unit is controlled by another master in the system

EXTERNAL RESET - internal jumper plug to enable or inhibit effect of incoming reset signal, permitting recycle or cumulative operation mode (shipped in ENB position)

DISPLAY - front panel pushbutton to cause contents of timer to be displayed on an associated Model 1790C

PRINT - internal jumper plug to inhibit or enable print (shipped in ENB position)

Specifications(continued)

PERFORMANCE

CAPACITY - six decades, allowing full scale time range of 10^5-1 seconds (27.8 hours) or 10^5-1 minutes (69.4 days)

TIME BASE ACCURACY - controlled by quartz crystal oscillator, accuracy of 0.002% over operating temperature range

TEMPERATURE OPERATING RANGE - 0 to 50°C

INDICATORS

TIMING - front panel light is illuminated during accumulation and extinguished when a stop command is initiated or preset is reached

DISPLAY - front panel light serves to indicate contained data is available at rear panel control output connector for display on a Canberra Model 1790C

CONNECTORS

GATE IN, GATE OUT - front, BNC UG-1094/U

CONTROL INPUT - rear, Amphenol 17-20150

CONTROL OUTPUT - rear, Amphenol 17-10150

POWER

+24V — 0mA +12V — 110mA
-24V — 0mA -12V — 15mA
115VAC — 85mA (A.C. line protection via rear panel 1/4 Amp SLO BLO fuse)

PHYSICAL

SIZE - standard single width module (1.35 inches wide) (3.43 cm) per TID-20893

NET WEIGHT - 2.5 lbs. (1.125 kgs)

SHIPPING WEIGHT - 7.5 lbs. (3.37 kgs)

IN
OUT
1/4A. SLO BLO
FUSE

Model 1770 Timer/Scaler

Features

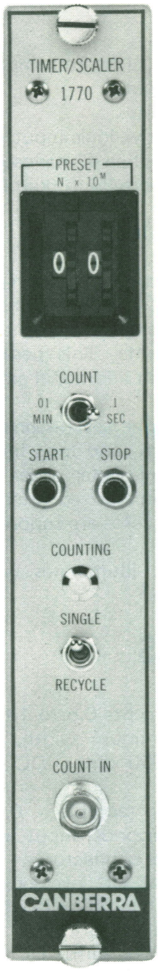
- Preset timer or scaler operation
- Electronic gating capability
- Five decade count capacity
- Line frequency or optional crystal time base

Description

The Canberra Model 1770 Timer/Scaler can function as an interval timer, a preset count scaler, or as a digital divider. The time base of the Model 1770 is derived from the power line frequency (crystal optional) and is switch selected for a 0.1 second or 0.01 minute interval.

Independent thumbwheel switches select the preset limit. The N switch selects a multiplier (1-9) and the 10^M switch selects a power of 10 (10^0 - 10^5) by which it is multiplied. A front panel switch determines the preset base (0.01 min./count/0.1 sec.).

Rear panel connectors permit external starting and gating of the Model 1770. A gate output, which is high while the unit is counting, is provided. In addition, a stop output pulse, which can be used to initiate system printout with all standard Canberra output scanners, is available.



Specifications

INPUTS

COUNT IN - accepts positive pulses greater than +3 volts; pulse width, 100nsec; rise and fall time should be less than 10μsec; front panel BNC connection; input impedance >1K ohms; pulse pair resolution, 200nsec

START IN - accepts a positive pulse to initiate counting; amplitude must be greater than +3 volts; an open circuit is considered as 0 volts; rear panel BNC connector; input impedance >1 K ohms

GATE IN - a +3 to +10 volt DC level of pulse (or open circuit) enables counting; less than a 0.8 volt DC level or pulse (or short circuit) inhibits counting; rear panel BNC connector; input impedance >1 K ohms

OUTPUTS

STOP OUT - 500 nanosecond positive, +5 volts amplitude; occurs when preset is reached; rear panel BNC connector

GATE OUT - provides a +5 volt DC level during counting, +0.5 volt DC level when not counting (except when inhibited by Gate Input) rise time less than 200 nanoseconds; will gate up to 50 compatible timers and scalers; rear panel BNC connector

FRONT PANEL CONTROLS

START - pushbutton to begin operation; resets all decades to zero, then initiates counting

STOP - pushbutton to terminate operation

PRESET - two-digit thumbwheel switches to preset time or counts; selectable preset limit is N x 10^M, where N is the Multiplier (0-9) and 10^M is the power of ten (0-5) being multiplied, N=0 disables the preset

0.01 MIN/COUNT/0.1 SEC - determines the base to be affected by the preset

MODE - toggle switch to select Single or Recycle mode of operation when preset is reached

INTERNAL CONTROLS

GATE MODE - jumper plugs allow the GATE input to control the counting channel or GATE OUT or BOTH

PERFORMANCE

CAPACITY - five decades; 10^5 - 1 counts

PULSE PAIR RESOLUTION - 200nsec

TIME BASE ACCURACY - line frequency accuracy ≈0.1% (or if the crystal controlled option is present, 0.007%)

INDICATORS

COUNT - front panel light is illuminated during counting, and not illuminated when preset is reached or the unit is manually stopped

CONNECTORS

COUNT IN - front panel, BNC, UG-1094/U

START IN, GATE IN, STOP OUT, GATE OUT - rear panel, BNC, UG-1094/U

OPTION - crystal time base, $75.00 (Specify Model 1770C)

POWER

+24V — 0mA +12V — 25mA
- 24V — 0mA - 12V — 0mA
115VAC — 75mA

PHYSICAL

SIZE - standard single width NIM module (1.35 inches wide) (3.43 cm) per TID-20893 (rev.A)

NET WEIGHT - 2.3 lbs. (1.04 kgs.)

SHIPPING WEIGHT — 7.3 lbs. (3.3 kgs.)

Model 1771
Scaler

Features

- Solid state LED display (Light-Emitting Diodes)
- Built-in integral discriminator
- Electronic gating capability
- Accepts positive or negative logic input
- Pulse pair resolution less than 40 nanoseconds
- Seven decade count capacity with built-in prescaler

Description

The Canberra Model 1771 is a 25MHz non-printing scaler featuring front panel Start, Stop, Reset, and Discriminator controls. Electronic gating circuitry provides the capability of externally inhibiting the scaler from accumulating counts. This permits simple coincidence experiments without the need for additional gating modules.

The six numeric indicators utilize seven-segment light-emitting diodes to provide solid state reliability and long life. Because this is a flat surface display, the viewing angle is far wider than that obtained with tube type display. A circularly-polarized filter allows brilliant readout even in direct sunlight. Leading zeros are suppressed for viewing ease.

A front panel indicator light illuminates when the scaler is in a condition to accept input pulses.

Specifications

INPUTS

POSITIVE SIGNAL IN - accepts 0.5 to 10 volt (50 volt maximum) pulses; any rise time; minimum width, 20 nanoseconds; input impedance greater than 1000 ohms, DC coupled; front and rear panel BNC connectors

NEGATIVE SIGNAL IN - accepts - 0.6 to - 2.0 volt pulses; minimum width, 20 nanoseconds; input impedance 50 ohms; DC coupled; front and rear panel connectors

GATE IN - +3 to +10 volt DC level or pulses (or open circuit) enables accumulation; less than 0.8 volt DC level or pulse (or short circuit) inhibits accumulation; 3mA current sinking; input impedance greater than 1000 ohms, DC coupled; front and rear panel BNC connectors

OUTPUTS

OVERFLOW - +5 volt pulses at reset of sixth decade; rise time less than 200 nanoseconds, width 5 microseconds; DC coupled; rear panel BNC connector

FRONT PANEL CONTROLS

START - pushbutton to initiate accumulation

STOP - pushbutton to terminate accumulation

RESET - pushbutton to reset all decades to zero

NEG./POS. - toggle switch to select input pulse polarity

DISC. - screwdriver adjust to inhibit counting of input pulses below selected level from +0.5 to +10 volts

INTERNAL CONTROLS

PRESCALER - two jumper plugs to insert a decade prescaler in the counting channel: this prescaler is not displayed

PERFORMANCE

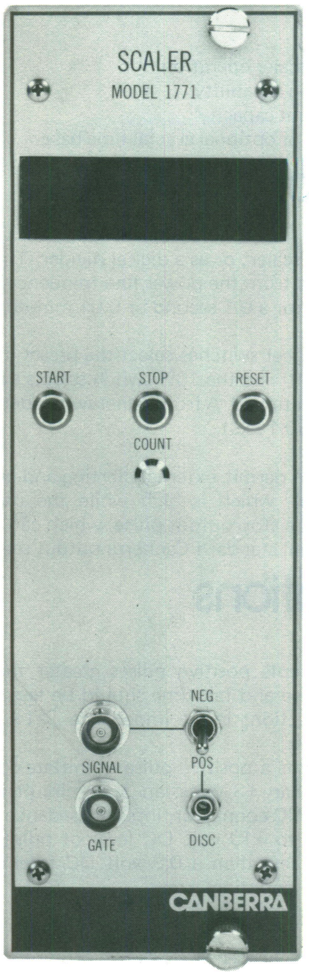
CAPACITY - six decades, allowing 10^6-1 counts; a non-displaying prescaling decade may be selected by internal jumper

COUNT RATE - 25MHz minimum, 30 MHz typical

PULSE PAIR RESOLVING TIME - less than 40 nanoseconds

TEMPERATURE OPERATING RANGE - 0 - 50°C

AUTOMATIC RESET - initiated when power is first turned on or after power fails, resets all decade counters to zero



INDICATORS

VISUAL DISPLAY - six solid state numeric indicators; leading zeros suppressed

COUNT - front panel light is illuminated during accumulation and extinguished when a stop command is initiated

CONNECTORS

INPUT - front panel and rear, BNC, UG-1094/U

GATE - front panel and rear, BNC, UG-1094/U

OVERFLOW - rear panel, BNC, UG-1094/U

POWER

+24V	—	0mA	+12V	—	50mA
- 24V	—	0mA	- 12V	—	150mA

115VAC —150mA

PHYSICAL

SIZE - standard double width modules (2.70 inches wide) (6.85 cm) per TID-20893

NET WEIGHT - 3.25 lbs. (1.47 kgs.)

SHIPPING WEIGHT - 8.25 lbs. (3.71 kgs.)

Model 1772 Counter/Timer

Features

- Timer and scaler operation
- Solid state LED display (Light-Emitting Diodes)
- Built-in integral discriminator
- Electronic gating capability
- Accepts positive or negative logic input
- Pulse pair resolution less than 40 nanoseconds
- Seven decade count capacity with built-in prescaler

Description

The Canberra Model 1772 Counter/Timer combines in a dual-width NIM module one six-decade (crystal optional) 25MHz non-printing scaler slaved to an internal line frequency timer. The module may function as a system master to control the duration of counting experiments on the basis or preset time utilizing electronic gating techniques.

Independent thumbwheel switches select the preset time limit for the switch selectable time base of 0.1 seconds or 0.01 minutes. The N switch selects a multiplier (0-9) and the 10^M switch selects the power of ten (10^0 - 10^5) by which it is multiplied.

The scaler input is equipped with an integral discriminator covering an input voltage range of +0.5 to +10 volts by means of a front panel screwdriver adjustment. This discriminator can replace a separate integral discriminator in many counting systems.

The six numeric indicators utilize seven-segment light-emitting diodes to provide solid state reliability and long life. Because this is a flat surface display, the viewing angle is far wider than that obtained with tube display. A circularly-polarized filter allows brilliant readout even in direct sunlight. Leading zeros are suppressed for viewing ease.

The counter/timer may operate in Single (one cycle) or Recycle modes. In single mode, counting stops when the preset time is reached and the unit will await new manual commands. In Recycle mode, counting stops momentarily for ≈ 2 seconds, then the timer and scaler are reset and counting begins again.

The Model 1772 Counter/Timer features fast gating capability. An internal jumper allows the gate input to control only the scaler or both the timer and the scaler. The gate output is controlled by the preset time or by the stop pushbutton and is activated until preset is reached or the stop pushbutton is depressed, except when inhibited by the gate input signal. A front panel indicator lights when the scaler is in a condition to accept counts.

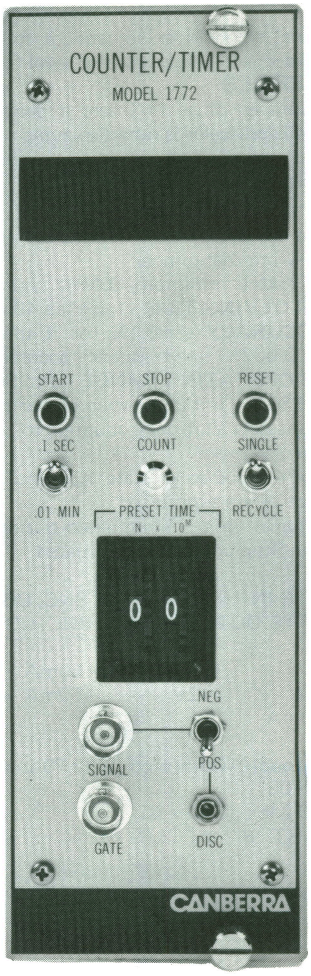
Front panel Start, Stop and Reset pushbutton switches are provided for manual control of the nuclear counter

Specifications

INPUTS

POSITIVE SIGNAL IN - accepts 0.5 to 10 volts (+50 volt maximum) pulses; any rise time; minimum pulse width, 20 nanoseconds; input impedance greater than 1000 ohms; DC coupled; front and rear panel BNC connectors

NEGATIVE SIGNAL IN - accepts -0.6 to -2.0 volt pulses; minimum width, 20 nanoseconds; input impedance 50 ohms; DC coupled; front and rear panel BNC connectors



GATE IN - +2 to +10 volt DC level or pulses (or open circuit) enables accumulation; less than 0.8 volt DC level or pulse (or short circuit) inhibits accumulation; 3mA current sinking; input impedance greater than 1000 ohms, DC coupled, front and rear panel BNC connectors

OUTPUTS

OVERFLOW - +5 volt pulses at reset of sixth decade; rise time less than 200 nanoseconds, width 5 microseconds; DC coupled; rear panel BNC connector

GATE OUT - provides +5 volt DC level during accumulation, +0.5 volt DC level when not accumulating (except when inhibited by Gate Input); rise time less than 200 nanoseconds; will gate up to 50 compatible scalers and timers; current sinking 150MA, DC coupled; rear panel BNC connector

FRONT PANEL CONTROLS

START - pushbutton to renew or begin accumulation

STOP - pushbutton to terminate accumulation

Specifications(continued)

RESET - pushbutton to reset all decades to zero; accumulation will begin unless the Stop pushbutton is first depressed

MODE - toggle switch to select Single or Recycle mode of operation upon reaching a preset condition

PRESET - two digit thumbwheel switches for the time base; selectable preset limit is $N \times 10^M$, N is the 0-9 digit multiplier and 10^M is the power of ten being multiplied; N = 0 is preset OFF, disabling the preset functions of the time base

NEG./POS. - front panel toggle switch to select input pulse polarity for the scaler

DISC. - front panel screwdriver adjustment to inhibit counting of input pulses to the scaler below selected level from +0.5 to 10 volts

INTERNAL CONTROLS

PRESCALER - jumper plugs to insert a decade prescaler in the desired channel; this prescaler is non-displaying

GATE MODE - jumper plug allows the gate input to control either the scaler or both the timer and the scaler

PERFORMANCE

CAPACITY - six decades; 10^6-1 counts; a non-displaying decade may be selected by internal jumper

COUNT RATE - 25MHz minimum, 30MHz typical

PULSE PAIR RESOLVING TIME - less than 40 nanoseconds

TIME BASE ACCURACY - ≈0.1% (or if the crystal controlled option is present, 0.007%) line frequency accuracy

TEMPERATURE OPERATING RANGE - 0 to 50°C

AUTOMATIC RESET - initiated when power is first turned on or after power failed; resets all decade counters to zero

INDICATORS

VISUAL DISPLAY - six solid state numeric indicators for each channel; leading zeros are suppressed

COUNT - front panel light is illuminated during accumulation and extinguished when Stop command is initiated

CONNECTORS

SIGNAL IN, GATE IN - front and rear, BNC, UG-1094/U

OVERFLOW, GATE OUT - rear panel, BNC, UG-1094/U

POWER

+24V — 0mA   +12V — 50mA
-24V — 0mA   -12V — 150mA
115VAC — 200mA

PHYSICAL

SIZE - standard double width module (2.70 inches wide) (6.85 cm wide) per TID-20893

NET WEIGHT - 3.2 lbs. (1.47 kgs)

SHIPPING WEIGHT - 8.2 lbs. (3.69 kg)

Model 1773
Scaler

Features

- Solid state LED display (Light-Emitting Diodes)
- Built-in integral discriminator
- Electronic gating capability
- Accepts positive or negative logic input
- Printout capability with standard Canberra NIM modules
- Pulse pair resolution less than 40 nanoseconds
- Seven decade count capacity with built-in prescalers

Description

The Model 1773 Scaler can operate independently as a 25MHz Printing Scaler, or may function as a system slave, counting at a 25MHz rate when enabled by a Model 1776 Dual Counter/Timer or Model 1790C Universal Counter.

In either role the six decade Model 1773 provides a serial BCD readout capability compatible with Teletype, punched paper tape, or magnetic tape data acquisition equipment when controlled by the Model 1488 or 1487, Printing Control modules respectively. Printout may be inhibited by a rear panel switch.

The six numeric indicators utilize seven-segment light-emitting diodes to provide solid state reliability and long life. Because this is a flat surface display, the viewing angle is far wider than that obtained with tube type display. A circularly-polarized filter allows brilliant readout even in direct sunlight. Leading zeros are suppressed for easy reading.

Electronic gating circuitry provides the capability of externally inhibiting the scaler from accumulating counts. This permits simple coincidence experiments without the need for additional gating modules. A front panel indicator light is illuminated when the scaler is in a condition to accept input pulses.

Specifications

INPUTS

SIGNAL

POS - +0.5 to 10 volt (50 maximum) pulses; any rise time; minimum pulse width, 20 nanoseconds; input impedance greater than 1000 ohms; DC coupled; front and rear panel BNC connectors

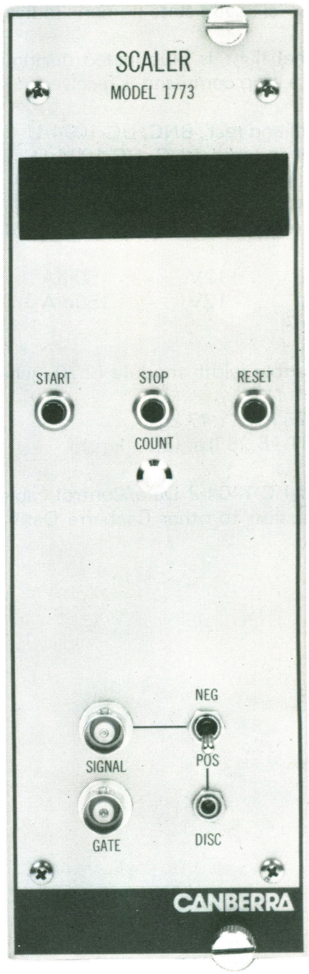
NEG - -0.6 to -2 volt pulses, 20 nanoseconds minimum pulse width; input impedance 50 ohms; DC coupled; front and rear panel BNC connectors

GATE - +3 to +10 volt DC level or pulses (or open circuit enables accumulation); less than 0.8 volt DC level or pulse (or short circuit) inhibits accumulation; input impedance greater than 1000 ohms, DC coupled, front and rear panel BNC connectors.

CONTROL INPUT - rear panel Amphenol 17-10150 15-pin connector accepts START, STOP, RESET, and PRINT commands: 5 volt negative-going pulses from +5 volt level, rise time 500 nanoseconds maximum, width 1 microsecond minimum; also accepts HOLD command; DC level change from +5 volts to +0.5 volts maximum during printout

OUTPUTS

CONTROL OUTPUT - rear panel Amphenol 17-20150 15-pin connector provides DATA OUTPUT; decimal digit serial 1-2-4-8 BCD; logic 1 = +4 volts DC, logic 0 = 0 volts DC; connector also provides "next unit" print command; eight and successive PRINT command input pulses are routed out via logic gate; all control lines except PRINT command are wired directly between CONTROL INPUT-CONTROL OUTPUT connectors



OVERFLOW - +5 volt pulses at reset of sixth decade; rise time less than 200 nanoseconds, width 5 microseconds; DC coupled; rear panel BNC connector

FRONT PANEL CONTROLS

START - pushbutton to initiate accumulation

STOP - pushbutton to terminate accumulation

RESET - pushbutton to reset all decades to zero

NEG/POS - switch to select input pulse polarity

DISC - screwdriver adjust to inhibit counting of input pulses below selected level from +0.5 to +10 volts

REAR PANEL CONTROLS

PRINT - switch to enable (PRINT) or inhibit (SKIP) printout of the scaler

INTERNAL CONTROLS

PRESCALER - jumper plug to insert a decade prescaler in the counting channel; this prescaler is non-displaying and is not printed out

EXTERNAL RESET DISABLE - jumper plug may be inserted to inhibit response of the module to reset commands received via the Model C-1404 control cable for cumulative count: thus, the scaler may only be reset by front panel switch

Specifications(continued)

PERFORMANCE

CAPACITY - six decades, allowing 10^6-1 count: a non-displaying prescaling decade may be selected by internal jumper

COUNT RATE - 25MHz minimum, 30MHz typical

PULSE PAIR RESOLVING TIME - <40 nanoseconds

TEMPERATURE OPERATING RANGE - 0 - 50°C

AUTOMATIC RESET - initiated when power is first turned on or after power fails, resets all decades counters to zero

INDICATORS

VISUAL DISPLAY - six solid state numeric indicators: leading zeros suppressed

COUNT -front panel light is illuminated during accumulation and extinguished when a stop command is received

CONNECTORS

INPUT - front panel and rear, BNC, UG-1094/U

GATE - front panel and rear, BNC, UG-1094/U

OVERFLOW - rear panel, BNC, UG-1094/U

CONTROL IN - rear panel, Amphenol 17-10150

CONTROL OUT - rear panel, Amphenol 17-20151

POWER

+24V	—	0mA	+12V	—	50mA
- 24V	—	0mA	- 12V	—	150mA
115VAC	—	150mA			

PHYSICAL

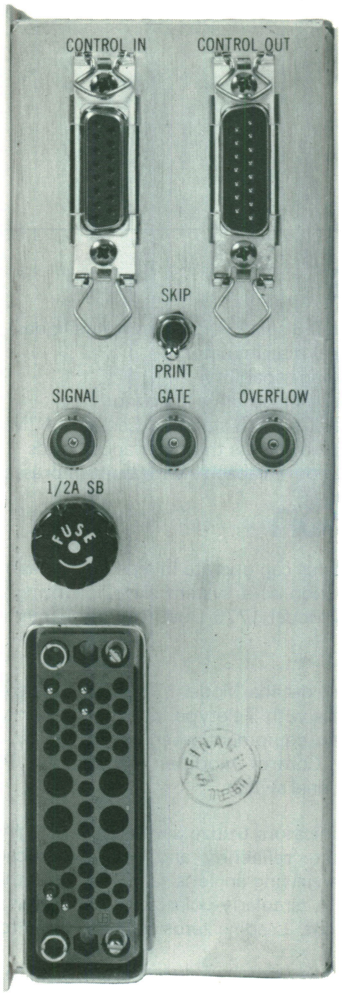
SIZE - standard double width module (2.70 inches wide) (6.86 cm) per TID-20893

NET WEIGHT - 3.25 lbs. (1.47 kgs.).

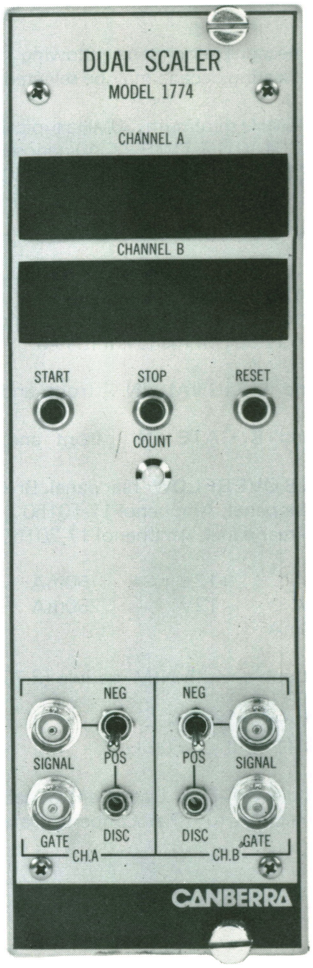
SHIPPING WEIGHT - 8.25 lbs. (3.71 kgs.).

ACCESSORIES

One Canberra Model C-1404-2 Data/Control cable 2 ft. in length is supplied for connection to other Canberra Date Acquisition Series Modules.



Model 1774
Dual Scaler



Features

- Two scalers in a single module
- Solid state LED displays (Light-Emitting Diodes)
- Built-in integral discriminator in each channel
- Electronic gating capability in each channel
- Accepts positive or negative inputs
- Printout capability with standard Canberra print/control NIM modules
- Pulse pair resolution <40 nanoseconds
- Seven decade count capacity with built-in prescalers

Description

The Model 1774 Dual Scaler contains two independent 25MHz printing scalers. Each scaler can operate alone or may function as a system slave, counting at a 25MHz rate when enabled by a Model 1776 Dual Counter/Timer or Model 1790C Universal Counter.

The Model 1774 provides a serial BCD readout from both scalers which is compatible with the Canberra Daisy Chain for readout options such as TTY, RS232 and all Canberra NIM I/O devices.

The six numeric indicators in each Scaler utilize seven segment light-emitting diodes to provide solid state reliability and long life. Because this is a flat surface display, the viewing angle is far wider than that obtained with tube type display. A circularly-polarized filter allows brilliant readout even in direct sunlight. Leading zeros are suppressed for easy reading.

Electronic gating circuitry provides the capability of externally inhibiting either scaler from accumulating counts. This permits simple coincidence experiments without the need for additional gating modules.

A front panel indicator light illuminates when the scalers are in a condition to accept input pulses.

Specifications

INPUTS

POSITIVE SIGNAL IN - two independent counting channels; identified as Channel A and Channel B; accept +0.5 to +10 volt (50 volt maximum) pulses; any rise time; minimum width, 20 nanoseconds; input impedance greater than 1000 ohms, DC coupled; front and rear panel BNC connectors

NEGATIVE SIGNAL IN - two independent counting channels; identified as Channel A and Channel B; accepts - 0.6 to - 2.0 volt pulses; minimum width, 20 nanoseconds, input impedance 50 ohms; DC coupled; front and rear panel BNC connectors

GATE IN - two independent gate inputs, Channel A and Channel B; +3 to +10 volt DC level or pulses (or open circuit) enables accumulation; less than 0.8 volt DC level or pulse (or short circuit) inhibits accumulation; 3mA current, sinking; input impedance greater than 1000 ohms, DC coupled; front and rear panel BNC connectors

CONTROL INPUT - rear panel Amphenol 17-10150 15-pin connector accepts Start, Stop, Reset, and Print commands; 5-volt, negative-going pulses from +5 volt level, rise time 500 nanoseconds maximum, width 1 microsecond minimum; also accepts HOLD command; DC level change from +5 volts to +0.5 volts maximum during printout

OUTPUTS

CONTROL OUTPUT - rear panel Amphenol 17-20150 15-pin connector provides Data Output; decimal digit serial 1-2-4-8 BCD logic 1 = +4 volts, DC, logic 0 = 0 volts DC; connector also provides "next unit" print command; eight and successive Print command input pulses are routed out via logic gate; all control lines except PRINT command are wired directly between CONTROL INPUT-CONTROL OUTPUT connectors

OVERFLOW - two independent overflow outputs, Channel A and Channel B; +5 volt pulses at reset of sixth decade; rise time less than 200 nanoseconds, width 0.5 microseconds; DC coupled; rear panel BNC connectors

FRONT PANEL CONTROLS

START - pushbutton to initiate accumulation

STOP - pushbutton to terminate accumulation

RESET - pushbutton to reset all decades to zero

NEG./POS. - two toggle switches to select input pulse polarity for Channel A and Channel B

DISC. - two screwdriver adjustments to inhibit counting of input pulses to Channel A and Channel B below selected level from +0.5 to +10 volts

REAR PANEL CONTROLS

PRINT - two toggle switches (Channel A and Channel B) to enable (PRINT) or inhibit (SKIP) printout of either or both of the two scalers

Specifications(continued)

INTERNAL CONTROLS

PRESCALER - two jumper plugs per channel to insert a decade prescaler in the desired channel; these prescalers are non-displaying and are not printed out.

EXTERNAL RESET DISABLE - two jumper plugs are available for insertion in desired channel(s) to inhibit response of the module to reset commands received via the Model C-1404 control cable for cumulative count: thus, the scalers may only be reset by front panel control

PERFORMANCE

CAPACITY - six decades per channel, allowing 10^6-1 counts each: a non-displaying prescaling decade may be selected for each channel by internal jumpers

COUNT RATE - 25MHz minimum, 30MHz typical

PULSE PAIR RESOLVING TIME - <40 nanoseconds

TEMPERATURE OPERATING RANGE - 0-50°C

AUTOMATIC RESET - initiated when power is first turned on or after power fails, resets all decade counters to zero

INDICATORS

VISUAL DISPLAY - two channels, each with six solid state numeric indicators: leading zeros suppressed

COUNT - front panel light is illuminated during accumulation and extinguished when a stop command is initiated

CONNECTORS

CHANNEL A and B SIGNAL IN - front and rear panel, BNC, UG-1094/U

CHANNEL A and B GATE IN - front and rear panel, BNC, UG-1094/U

CHANNEL A and B OVERFLOW - rear panel, BNC, UG-1094/U

CONTROL IN - rear panel, Amphenol 17-10150

CONTROL OUT - rear panel, Amphenol 17-20150

POWER

+24V — 0mA   +12V — 50mA
-24V — 0mA   -12V — 250mA
115VAC — 250mA

PHYSICAL

SIZE - standard double-width NIM module (2.70 inches wide) (6.85 cm) per TID-20893 (rev.)

NET WEIGHT - 4 lbs. (1.8 kgs).

SHIPPING WEIGHT - 9 lbs. (4.05 kgs).

ACCESSORIES

One Canberra Model C-1404-2 Data Control cable 2 ft. in length is supplied for connection to other Canberra Data Acquisition Series modules.

Model 1775
Nuclear Counter

Features

- Timer and scaler operation
- Solid state LED display (Light-Emitting Diode)
- Preset time or count operation
- Built-in integral discriminator
- Electronic gating capability
- Positive or negative logic input
- Printout capability with standard Canberra NIM modules
- Pulse pair resolution less than 40 nanoseconds

Description

The Canberra Model 1775 Nuclear Counter combines, in a dual-width NIM module, two six-decade scalers, one for counting time and the other for counting input pulses. The Model 1775 may be preset for either count or time. An internal crystal clock provides a 0.01 minute or 0.01 second time base. The module may function as a system master in large-scale printing counting systems.

Independent thumbwheel switches select the preset count or time limit. The N switch selects a Multiplier (0-9) and the 10^M switch selects a power of ten (10^0-10^5) by which it is multiplied. Other features include: front panel independent electronic gating; integral discrimination (+0.5 to +10 volt range) of input signals; manual start, stop, and reset controls; single and recycle modes of operation; positive and negative input pulse selection; and rear panel GATE OUT connector for gating up to 50 compatible scalers and timers.

Accumulated data printout of the internal scaler and timer is accomplished with standard Canberra Print/Control NIM modules such as the Model 1488 Teletype Scanner. Printout of either channel may be inhibited by rear panel switch. When employed in a printing system, the printout controller generally establishes single or recycle mode of operation. In a non-printing system, the Model 1775 may be operated in either the single or recycle mode. In the recycle mode the display time between recycles is internally adjustable from 1 to 5 seconds.

The Model 1775 display utilizes light-emitting diodes to provide solid state reliability and long life. Because this is a flat-surface display, the viewing angle is far wider than that obtained with tube type displays. A circularly polarized filter allows brilliant readout even in direct sunlight. In operation, the "SLAVE" scaler is always displayed. That is, when operating in Preset time, the counts are displayed, and vice versa.

Specifications

INPUTS

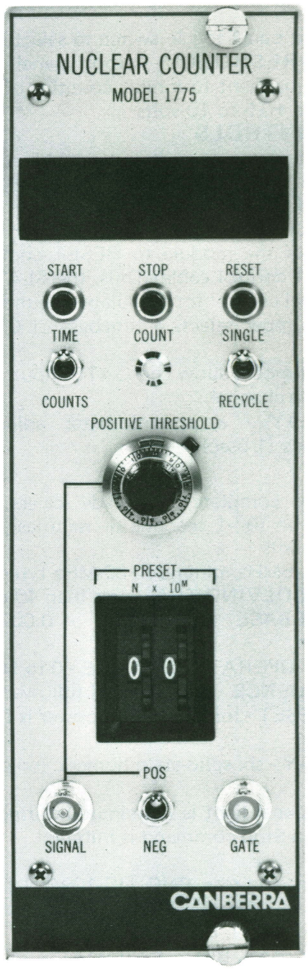
SIGNAL

Pos. - accepts +0.5 to +10 volts (+50 volt maximum) pulses; any rise time; minimum pulse width, 20 nanoseconds; input impedance greater than 1000 ohms; DC coupled; front and rear panel BNC connectors

Neg. - 0.6 to - 2 volt pulses; 20 nanoseconds minimum pulse width; input impedance 50 ohms; DC coupled; front and rear panel connectors

GATE - +3 to +10 volt DC level or pulses (or open circuit) enables accumulation; less than 0.8 volt DC level or pulse (or short circuit) inhibits accumulation; input impedance greater than 1000 ohms, DC coupled, front and rear panel connectors

CONTROL IN - accepts START, STOP, RESET, PRINT (5 volt negative-going pulses from +5 volt level, rise time 500 nanoseconds maximum); width 1.0 microsecond minimum, and HOLD commands (DC level change from +5 volts to +0.5 volts maximum during printout); rear panel Amphenol 17-10150 15-pin connector



OUTPUTS

OVERFLOW - +5 volt pulses at reset of sixth decade; rise time less than 200 nanoseconds, width 0.5 microseconds; DC coupled; rear panel BNC connector

GATE OUT - provides +5 volt DC level during accumulation, +0.5 volt DC level when not accumulating (except when inhibited by Gate Input); rise time less than 200 nanoseconds; will gate up to 50 compatible scalers and timers; current sinking 150mA, DC coupled; rear panel BNC connector

CONTROL OUT - provides START, STOP, and RESET commands (5 volt negative-going pulses from +5 volt level, rise time 500 nanoseconds maximum, width 1.0 microsecond minimum); data output information in the form of decimal digit serial 1-2-4-8 BCD; logic 1=+4 volts DC, logic 0=0 volts DC; connector also provides "next unit" PRINT command; eighth and successive PRINT command pulses are routed out via logic gate; all control lines except PRINT command are wired directly between Control Input-Control Output connectors; rear panel Amphenol 17-20150 15-pin connector

FRONT PANEL CONTROLS

START - manual pushbutton to renew or begin accumulation

STOP - manual pushbutton to terminate accumulation

Specifications(continued)

RESET - manual pushbutton to reset all decades to zero; accumulation will begin unless the stop pushbutton is first depressed

TIME/COUNT - two position toggle switch to select Preset Time or Preset Count operation

MODE - toggle switch to select Single or Recycle mode of operation upon reaching a preset condition

PRESET - two digit thumbwheel switch; selectable preset limit is N x 10^M N is the 0-9 digit multiplier and 10^M is the power of ten being multiplied; either channel N = 0 is preset OFF, disabling the preset function

NEG./POS. - front panel toggle switch to select input pulse polarity

POSITIVE THRESHOLD - front panel ten turn locking potentiometer adjustment to inhibit counting of input pulses below selected level from +0.5 to 10 volts

REAR PANEL CONTROLS

PRINT - rear panel toggle switch to enable (PRINT) or inhibit (SKIP) printout of either SLAVE or SLAVE and MASTER

INTERNAL CONTROLS

EXTERNAL RESET DISABLE - a jumper plug may be removed to inhibit response of the module to RESET commands received via the Model C-1404 control cable. Thus, the SLAVE may be RESET only by front panel control for cumulative counting

TIMEBASE - a jumper selects a timebase of 0.01 minute or 0.01 second

GATE INPUT - jumpers allow the GATE input to operate in either the Master or Slave channel

RECYCLE DELAY - a potentiometer adjusts time between counting operations (1-5sec)

PERFORMANCE

CAPACITY - two complete six decade scalers; each allows a full scale time range of 10^4-1 seconds or minutes, or full scale count range of 10^6-1 counts

COUNT RATE - 25MHz minimum, 30 MHz typical

PULSE PAIR RESOLVING TIME - less than 40 nanoseconds

CRYSTAL TIMEBASE ACCURACY - 0.007% over operating temperature range

TEMPERATURE OPERATING RANGE - 0 to 50°C

PRINTOUT SEQUENCE - slave channel followed by master

AUTOMATIC RESET - initiated when power is first turned on

INDICATORS

VISUAL DISPLAY - six solid-state numeric indicators; leading zeros are suppressed

COUNT - front panel light is illuminated during accumulation and extinguished when Stop command is initiated

CONNECTORS

SIGNAL IN - front and rear, BNC, UG-1094/U

GATE IN - front and rear, BNC, UG-1094/U

OVERFLOW - rear panel, BNC, UG-1094/U

GATE OUT - rear panel, BNC, UG-1094/U

CONTROL IN - rear panel, Amphenol, 17-10150

CONTROL OUT - rear panel, Amphenol, 17-20150

POWER

+24V — 0mA +12V — 50mA
-24V — 0mA -12V — 250mA
115VAC — 250mA

PHYSICAL

SIZE - standard double width module (2.70 inches wide) per TID-20893 (6.85 cm)

NET WEIGHT - 4 lbs. (1.82 kgs.)

SHIPPING WEIGHT - 9 lbs. (4.05 kgs.)

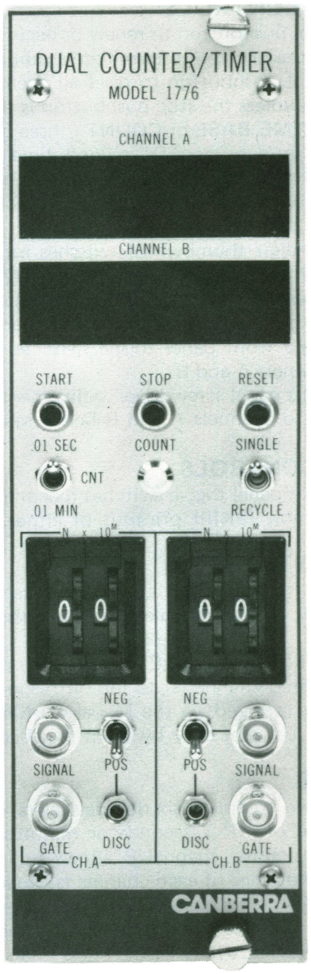
ACCESSORIES

One Canberra Model C-1404-2 Date/Control Cable 2 ft. in length is supplied for connection to other Canberra data acquisition series modules

Model 1776
Dual Counter/Timer

Features

- Dual scaler or timer and scaler operation
- Dual solid state LED display (Light-Emitting Diode)
- Preset time and/or count operation
- Built-in integral discriminators
- Electronic gating capability
- Positive or negative logic input for each scaler
- Printout capability with standard Canberra NIM modules
- Pulse pair resolution less than 40 nanoseconds
- Seven decade count capacity with built-in prescalers



Description

The Canberra Model 1776 Dual Counter/Timer combines in a dual-width NIM module two independent six decade scalers, plus an internal crystal controlled time base. Two presettable counting channels, identified as A and B permit preset count and preset time operation either separately or simultaneously. The module may function as a system master to control the duration of counting experiments on the basis of preset count and/or time, or may serve simply as a dual channel system slave, operating at counting rates up to 25MHz.

Independent thumbwheel switches select the preset count or time limit for each channel. The N switch selects a Multiplier (0-9) and the 10^M switch selects a power of ten (10^0-10^5) by which it is multiplied. Other features include: front panel independent electronic gating; integral discrimination (+0.5 to +10 volt range) of both channel A and B input signals; manual start, stop, and reset controls; single and recycle modes of operation; positive and negative input pulse selection on each channel; and a rear panel GATE OUT connector for gating up to 50 compatible scalers and timers.

Accumulated data printout of the two internal scalers is accomplished with standard Canberra Print/Control NIM modules such as the Model 1488 Teletype Scanner. Printout of either channel may be inhibited by rear panel switch. When employed in a printing system, the printout controller generally establishes single or recycle mode of operation. In a non-printing system, the Model 1776 may be operated in either the single or recycle mode. In the recycle mode the display time between recycles is internally adjustable from 1 to 5 seconds.

The Model 1776 display utilizes light-emitting diodes to provide solid state reliability and long life. Because this is a flat-surface display, the viewing angle is far wider than that obtained with tube type displays. A circularly polarized filter allows brilliant readout even in direct sunlight. Two sets of six numeric indicators display the contents of Channel A and B independently.

Channel A has the capability of presetting and counting either the internal time base (0.01 sec. or 0.01 min.) or the external A count input signals (CNT), depending upon the setting of the front panel channel A switch labeled .01 min/CNT/.01 sec. Channel B is a second scaler which is presettable and independent of channel A. The B scaler counts and displays the B count input signals.

Specifications

INPUTS

SIGNAL

POS. - channel A and B; accept +0.5 to +10 volts (+50 volt maximum) pulses; any rise time; minimum pulse width, 20 nanoseconds; input impedance greater than 1000 ohms; DC coupled; front and rear panel BNC connectors

NEG. - channel A and B; accept - 0.6 to - 2 volt pulses; 20 nanoseconds minimum pulse width; input impedance 50 ohms; DC coupled; front and rear panel connectors

GATE - channel A and B; +3 to +10 volt DC level or pulses (or open circuit) enables accumulation; less than 0.8 volt DC level or pulse (or short circuit) inhibits accumulation; input impedance greater than 1000 ohms, DC coupled, front and rear panel connectors

CONTROL IN - accepts START, STOP, RESET, PRINT (5 volt negative-going pulses from +5 volt level, rise time 500 nanoseconds maximum); width 1.0 microsecond minimum, and HOLD commands (DC level change from +5 volts to +0.5 volts maximum during printout); rear panel Amphenol 17-10150 15-pin connector

OUTPUTS

OVERFLOW - +5 volt pulses at reset of sixth decade; rise time less than 250 nanoseconds, width 0.5 microseconds; DC coupled; rear panel BNC connector

GATE OUT - provides +5 volt DC level during accumulation, +0.5 volt DC level when not accumulating (except when inhibited by Gate Input); rise time less than 25 nanoseconds; will gate up to 50 compatible scalers and timers; current sinking 150mA, DC coupled; rear panel BNC connector

Specifications(continued)

CONTROL OUT - provides START, STOP, and RESET commands (5 volt negative-going pulses from +5 volt level, rise time 500 nanoseconds maximum, width 1.0 microsecond minimum); data output information in the form of decimal digit serial 1-2-4-8 BCD; logic 1 = +4 volts DC, logic 0 = 0 volts DC; connector also provides "next unit" PRINT command; eighth and successive Print command pulses are routed out via logic gate; all control lines except Print command are wired directly between Control Input-Control Output connectors; rear panel Amphenol 17-20150 15 pin connector

FRONT PANEL CONTROLS

START - manual pushbutton to renew or begin accumulation

STOP - manual pushbutton to terminate accumulation

RESET - manual pushbutton to reset all decades to zero; accumulation will begin unless the stop pushbutton is first depressed

CHANNEL A TIME BASE or COUNT - three position toggle switch to select 0.01 minute or 0.01 second time base; CNT position permits channel A to function as a presettable counter

MODE - toggle switch to select Single or Recycle mode of operation upon reaching a preset condition

PRESET - two digit thumbwheel switches for each channel; selectable preset limit is N x 10^M, N is the 0-9 digit multiplier and 10^M is the power of ten being multiplied; either channel N = 0 is preset OFF, disabling the preset functions of that channel

NEG./POS. - two front panel toggle switches to select input pulse polarity for channels A and B

DISC. - two front panel screwdriver, adjustments to inhibit counting of input pulses to channels A and B below selected level from +0.5 to 10 volts

REAR PANEL CONTROLS

PRINT - two rear panel toggle switches (channels A and B) to enable (PRINT) or inhibit (SKIP) printout of either or both of the two scalers

INTERNAL CONTROLS

PRESCALER - jumper plugs to insert a decade prescaler in the desired channel; these prescalers are non-displaying and are not printed out

EXTERNAL RESET DISABLE - two jumper plugs are available for insertion in desired channel(s) to inhibit response of the module to reset commands received via the Model C-1404 control cable. Thus, the scalers may be reset only by front panel control for cumulative count

PERFORMANCE

CAPACITY - two complete six decade scalers; channel A allows full scale time range of 10^4-1 seconds or minutes, or full scale count range of 10^6-1 counts; channel B allows full scale count range of 10^6-1 counts; the range of each channel is expandable by a factor of 10 via internal selectable decade (÷10) prescalers

COUNT RATE - 25MHz minimum, 30MHz typical

PULSE PAIR RESOLVING TIME - less than 40 nanoseconds for both signal inputs

CRYSTAL TIME BASE ACCURACY - 0.005% over operating temperature range

TEMPERATURE OPERATING RANGE - 0 to 50°C

PRINTOUT SEQUENCE - channel A scaler, channel B scaler

AUTOMATIC RESET - initiated when power is first turned on or after power failed; resets all decade counters to zero

INDICATORS

VISUAL DISPLAY - six solid state numeric indicators for each channel; leading zeros are suppressed

COUNT - front panel light is illuminated during accumulation and extinguished when Stop command is initiated

CONNECTORS

CHANNEL A and B SIGNAL IN - front and rear, BNC, UG-1094/U

CHANNEL A and B GATE IN - front and rear, BNC, UG-1094/U

CHANNEL A and B OVERFLOW - rear panel, BNC, UG-1094/U

GATE OUT - rear panel, BNC, UG-1094/U

CONTROL IN - rear panel, Amphenol, 17-10150

CONTROL OUT - rear panel, Amphenol, 17-20150

POWER

+24V — 0mA +12V — 50mA
-24V — 0mA -12V — 250mA
115VAC — 250mA

PHYSICAL

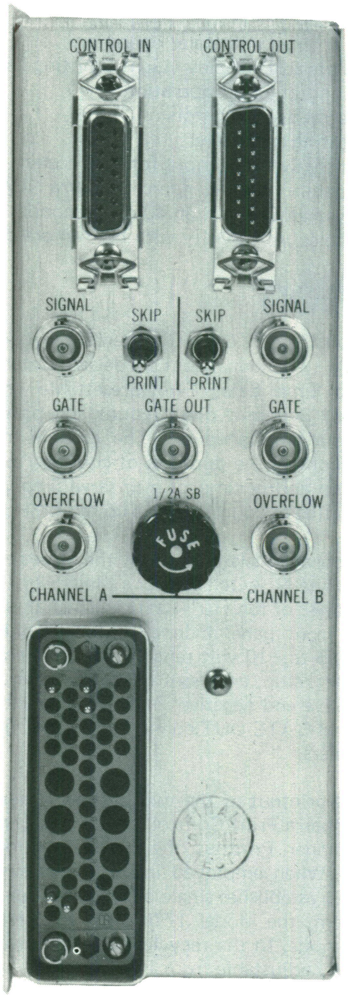
SIZE - standard double width module (2.70 inches wide) (6.85 cm) per TID-20893

NET WEIGHT - 4 lbs (1.82 kgs)

SHIPPING WEIGHT - 9 lbs (4.05 kg)

ACCESSORIES

One Canberra Model C-1404-2 Data/Control Cable 2 ft. in length is supplied for connection to other Canberra data acquisition series modules



Model 1784 Data Buffer

Features

- One unit buffers a complete counting system
- 18 (optional 36) timers, scalers, etc. per buffer module
- Extremely low "per scaler" buffer cost
- Allows essentially dead-timeless counting
- May be used with any Canberra printing system and I/O Scanner

Description

The Model 1784 System Buffer permits the data stored in up to 18 (optional 36) printing timers, scalers, etc. to be read out at the rate of 100μsec per scaler and stored in the Model 1784 buffer memory. The data acquisition system is then free to resume counting while I/O proceeds from the Model 1784 to the readout device. The result is effectively a dead-timeless system at a very low buffer cost per scaler.

Figure #1 illustrates the use of the Model 1784. To the counting system, the 1784 appears to be a very high speed readout scanner; to the scanner the 1784 appears to be an 18 (optional 36) channel counting system.

Note that the Model 1784 output can also be connected to the Canberra Model 1485 System Multiplexer, allowing multiple dead-timeless counting systems to share a single read-out device.

The operational logic of the Model 1784 is as follows:

A. Counting system comes to a STOP, either manually or by reaching a preset.
B. The data is transferred to the 1784 at the rate of 100μsec per scaler.
C. At the completion of this transfer a RESET/START is issued allowing data acquisition to resume (assuming the 1784 is in RECYCLE mode).
D. The Model 1784 now issues a STOP to the read-out scanner, causing the data in the buffer to be printed.

If, during step D, the counting system should again reach preset, the 1784 will hold the system until the data read-out is finished. The sequence then continues with step B. No data is lost.

Specifications

INPUTS

SCALERS IN - rear panel, Amphenol 17-10150
SCANNER IN - rear panel, Amphenol 17-10150

OUTPUTS

SCALERS OUT - rear panel, Amphenol 17-20150
SCANNER OUT - rear panel, Amphenol 17-20150

CONTROLS

ON-OFF/RESET - 2 position toggle switch; in the OFF/RESET position the 1784 is disabled and its memory cleared; the ON position puts the buffer into use.

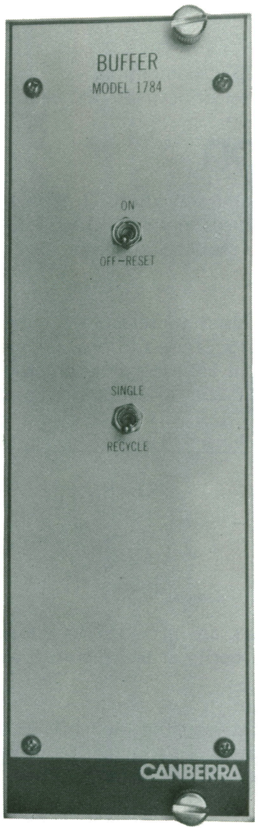
SINGLE-RECYCLE - determines mode of operation

PERFORMANCE

MEMORY
SIZE - 18 (optional 36) 6-digit numbers
SPEED - 100μsec per 6-digit number
TEMPERATURE OPERATING RANGE - 0-50°C ambient
PRINTOUT SEQUENCE - unit closest to SCALERS IN connector prints first

POWER

+12V — 20mA +24V — 0mA
-12V — 20mA -24V — 0mA
115VAC — 75mA (1/2A SLO BLO FUSE)



PHYSICAL

SIZE - standard double-width NIM module (2.70 x 8.71 inches (6.86 cm x 22.20 cm) per TID 20893 (rev.A)
NET WEIGHT - 3.4 lbs. (1.53 kgs).
SHIPPING WEIGHT - 8.4 lbs. (3.83 kgs).

ACCESSORIES

Two Canberra Model C-1404-2 Data/Control cables (2 ft.) are supplied with each unit.

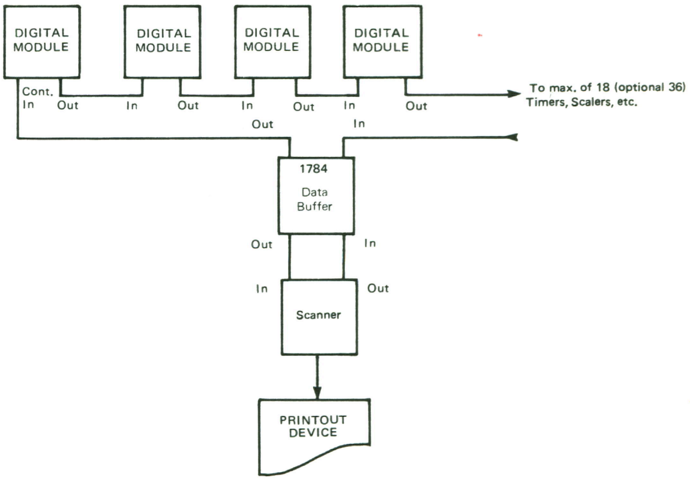


Figure 1

Model 1788
Communications Interface

Features

- Fully EIA RS-232C compatible
- Variable speed selection from 300 Baud to 9600 Baud

Description

The Model 1788 Communications Interface combines a Canberra "Daisy Chain" readout scanner and EIA RS-232C interface in a double width NIM module, to enable a computer to control the Canberra Daisy Chain.

Internal jumpers are used to select the data transmission rates. An internal crystal oscillator is used to provide a range of 300-9600 Baud. In addition, an external oscillator may be used to provide any desired rate over the range of 0-20,000 Baud. The standard selectable rates are:

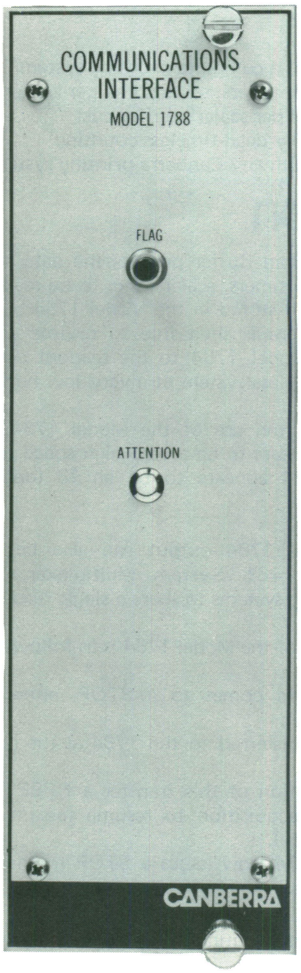
Baud Rate	Time to Read one Scaler
300	265ms
1200	66ms
2400	33ms
4800	16ms
9600	8.5ms

Other internal jumpers are provided to allow the user to select the existence and type of parity to be generated, and to select computer or modem operation.

All communication between the Model 1788 and the computer is via printing ASCII characters. This includes system control as well as data transfer. The ASCII control characters and their meaning are as follows:

Commands from 1788 to Computer		DESCRIPTION
!	(041_8)	The counting system has given a STOP (reached Preset) or, if a data transfer is in progress, the last scaler has all ready been readout
"	(042_8)	Generated by the front panel pushbutton
#	(043_8)	Generated by rear panel BNC input pulse or logic level

Commands from Computer To 1788		
R	$(122)_8$	Issue a system RESET
A	$(101)_8$	Illuminate the 1788 front panel lamp
S	$(123)_8$	Issue a system START
B	$(102)_8$	Turn off the 1788 front panel lamp
H	$(110)_8$	Issue a system STOP
X	$(130)_8$	Issue a logic pulse from the 1788 rear panel BNC
I	$(111)_8$	Force the system into PRINT and/or readout one scaler



The following is an example of how the above control characters are used

Computer ➞ 1788	1788 ➞ Computer	Action
R		RESET System
S		START system, then wait
	!	Preset has been reached
I	Scaler #1 Data	PRINT initiated and first data transferred
I	Scaler #2 Data	Data from second scaler
I	Scaler #3 Data	Data from third scaler
I	!	Transfer complete; there were only 3 scalers
X		Advance sample changer and wait
	#	Sample changer ready
R		RESET system
	etc.	

From the above example, the ease with which the Model 1788 can be controlled becomes apparent, allowing the experimenter to easily upgrade an off-line data acquisition system into an on-line acquisition and analysis system.

Specifications

INPUTS

CONTROL IN - Canberra "Daisy Chain" input; rear panel

SIGNAL (#) - Rear panel BNC; a low-to-high or high-to-low level shift (jumper selectable) will transmit a "#" to the computer; input impedance ≈3K ohms; a low voltage is - 15VDC to 0.8VDC; a high voltage is +3VDC to 15VDC

EXTERNAL RATE - Rear panel BNC; a TTL input for externally determining the Model 1788 Baud rate; input must be 16 times the desired rate

OUTPUTS

CONTROL OUT - Rear panel; Canberra "Daisy Chain" output

SIGNAL (X) - Rear panel BNC, Computer generated output; internal jumpers allow for

a. 4μsec Low to High pulse
b. 4μsec High to Low pulse
c. Level state (Low or High) corresponding to the state of the front panel indicator lamp

EIA DATA - Rear panel EIA RS-232C connector

CONTROLS/INDICATORS

FLAG - Front panel pushbutton which transmits a "character" to the computer

ATTENTION - Front panel indicator controlled by the computer

CONNECTORS

CONTROL INPUT - Rear panel, Amphenol # 17-10150
SIGNAL (#) - Rear panel BNC, # UG-1094/U
EXTERNAL RATE - Rear panel BNC, # UG-1094/U
CONTROL OUTPUT - Rear panel, Amphenol # 17-20150
SIGNAL (X) - Rear panel BNC, # UG-1094/U
DATA - Rear panel, standard EIA RS-232C connector

POWER

+24V	0mA	+12V	35mA
- 24V	0mA	- 12V	20mA

115VAC — 70mA (rear panel 1/2 amp S.B. fuse and holder)

PHYSICAL

SIZE - Standard double-width NIM module (2.70 x 8.71 inches) (6.85 x 22.19 cm) TID 20893 (rev.)

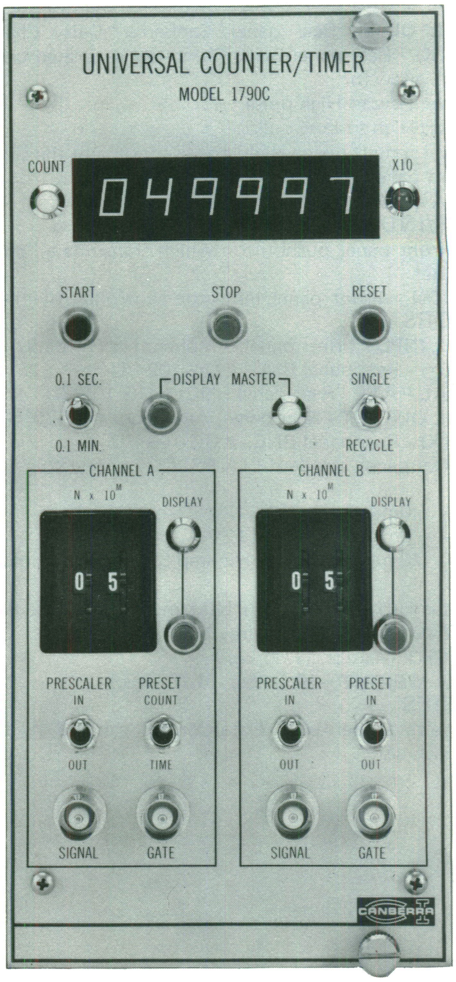
NET WEIGHT - 4.1 lbs. (1.86 kgs.)

SHIPPING WEIGHT - 9.1 lbs. (4.10 kgs.)

ACCESSORIES

One Canberra Model 1404 Data/Control cable 3 ft. in length is supplied with unit

Model 1790C
Universal Counter/Timer



Features

- Two scalers and one timer in a single module
- Solid state LED display (Light-Emitting Diodes)
- Display channel A or B or master or external Canberra blind NIM modules
- Preset time and/or preset count operation
- Seven decade count capacity with built-in prescalers
- Printout compatible with standard Canberra print/control modules
- Crystal controlled time base

Description

The Canberra Model 1790C Universal Counter/Timer is an all solid state extended capability counting instrument in a three-width NIM package. Its flexible design incorporates two independent six decade scalers, plus an internal timer. Two presetable counting channels, identified as A and B, have independent front panel switch selectable decade prescalers, allowing seven decade count and/or time capacity. Preset count and preset time operation may be performed either separately or both simultaneously, with manual or automatic operation.

The Model 1790C display utilizes light-emitting diodes to provide solid state reliability and long life. Because this is a flat-surface display, the viewing angle is far wider than that obtained with tube type displays. A circularly-polarized filter allows brilliant readout even in direct sunlight. The six numeric indicators display the contents of Channel A or B or Master via three independent front panel DISPLAY pushbuttons. Also, the Model 1790C can serve as a visual display for up to 50 Canberra Model 1476A Blind Scalers, or Model 1483A Parallel to Serial Converters, in a Canberra Nuclear Data Acquisition System.

Channel A contains two internal scalers; a presetable Master and a Slave. It has the capability of simultaneously counting the internal time base and the external A count input signals. Either the external A count input or the time base can be displayed. In PRESET COUNT position, the time base is the A Slave; in PRESET TIME position, the accumulated A count is the Slave. The internal time base is routed to the A Master scaler in PRESET TIME mode, and the A count input signals are connected to the A Slave scaler. In PRESET COUNT mode, the reverse is true. Channel B contains the third scaler which is presetable and independent of Channel A. The B scaler counts and displays the B count input signals.

Dual easy-to-read thumbwheel switches for each channel select the preset count or time limit. The N portion selects the multiplier (0-9) and the 10^M portion selects the power of ten (10^0-10^5) being multiplied. For example, if Channel B is preset for 5000 counts, N=5 and 10^M=3. When either channel preset limit is reached, both Channel A and B scalers will stop counting. With the Channel B PRESET switch in the OUT position, both channels will stop counting only when Channel A preset limit is reached.

Accumulated data printout of the three internal scalers is accomplished with standard Canberra Print/Control NIM modules such as the Model 1488 Teletype Scanner. The printout sequence is: Channel A Slave scaler, Channel A Master scaler, and Channel B scaler. Rear panel PRINT switches permit inhibiting the printout of Channel A Master scaler and/or Channel B scaler. In a non-printing system, the Model 1790C may be operated in SINGLE or RECYCLE mode of operation.

In the RECYCLE mode, the display time between recycles is internally adjustable from 1 to 5 seconds. When employed in a printing system, the printout controller, such as the Model 1488 Teletype Scanner establishes SINGLE or RECYCLE mode of operation.

Other features include: Crystal controlled time base selection of 0.1 seconds or 0.1 minutes, independent electronic gating and internally adjustable discrimination (+0.5 to +10V range) of the Channel A and B input signals, internal Reset A and Reset B jumper plugs to inhibit external electronic reset of Channel A Slave scaler and/or Channel B scaler, and rear panel GATE OUT connector for gating up to 50 compatible scalers and timers.

The Model 1790C also serves as a system Master; its Start, Stop, and Reset functions controlling (manually or automatically) an entire system of Canberra Data Acquisition Series modules, via the "daisy chain" hookup of Model C-1404 Data/Control cables.

Specifications

INPUTS

SIGNAL IN - two independent counting channels; identified as Channel A and B; accepts +0.5 to +10 volt (+25 volt maximum) pulses; any rise time; minimum width, 20 nanoseconds (duty cycle not to exceed 50% at maximum input count rate); input impedance 1K ohms, DC coupled; front and rear panel BNC connectors

GATE IN - two independent gate inputs, Channel A and B; +3 to +10 volts DC level or pulse (or open circuit) enables accumulation; less than +0.8 volt DC level or pulse (or short circuit) inhibits accumulation; 3mA current sinking; DC coupled; front and rear panel BNC connectors

CONTROL IN - accepts START, STOP, RESET, PRINT (5 volt negative-going pulses from +5 volt level, rise time 500 nanoseconds maximum; width 1.0 microsecond minimum), and HOLD commands (DC level change from +5 volts to +0.5 volts maximum during printout); also accepts DISPLAY BCD information in the form of decimal digit serial 1-2-4-8 BCD complement, where logic 1=0 volts and logic 0=+4 volts; rear panel Amphenol 17-10150 15 pin connector

OUTPUTS

CONTROL OUT - provides START, STOP, and RESET commands (5 volt negative-going pulses from +5 volt level, rise time 500 nanoseconds maximum, width 1.0 microsecond minimum); DATA OUTPUT information in the form of decimal digit serial 1-2-4-8 BCD, where logic 1=+4 volts and logic 0=0 volts; DISPLAY CLOCK command; 6kHz clock pulse train, +5 volt pulses, with a synchronization excursion to +12 volts every seventh pulse; connector also provides "next unit" PRINT command; the eighth, or fifteenth, or twenty-second (dependent on rear panel PRINT controls selection), and successive PRINT command input pulses are routed out via internal logic gates; all control lines except PRINT command are wired directly between corresponding pins of the CONTROL IN/OUT connectors; rear panel Amphenol 17-10150 15 pin connector

GATE OUT - provides +5 volt DC level during accumulation, +0.5 volt DC level when not accumulating (except when inhibited by Gate Input); rise time less than 25 nanoseconds, will gate up to 50 compatible scalers and timers; current sinking 150mA, DC coupled, rear panel BNC connector

FRONT PANEL CONTROLS

START - manual pushbutton to renew or begin accumulation

STOP - manual pushbutton to terminate accumulation

RESET - manual pushbutton to reset all decade counters to zero; accumulation will begin again unless the STOP pushbutton is first depressed

CHANNEL A TIME BASE - toggle switch to select 0.1 second or 0.1 minute time base

MODE - toggle switch to select SINGLE or RECYCLE mode of operation upon reaching a preset condition

PRESET - two digit thumbwheel switches for each channel; selectable preset limit is N x 10^M, N is the 0-9 digit multiplier and 10^M is the power of ten being multiplied; either channel N =) is preset OFF, disabling the preset functions of channel A and B (B PRESET switch IN)

DISPLAY - three independent manual pushbuttons, master, Channel A and B; to select scaler contents for visual readout on six digit numeric display

PRESET B ON/OFF - toggle switch to enable (IN) or disable (OUT) Channel B preset function; when IN, B scaler will stop whenever either A or B preset condition is reached; when OUT, Channel A preset condition will stop B scaler

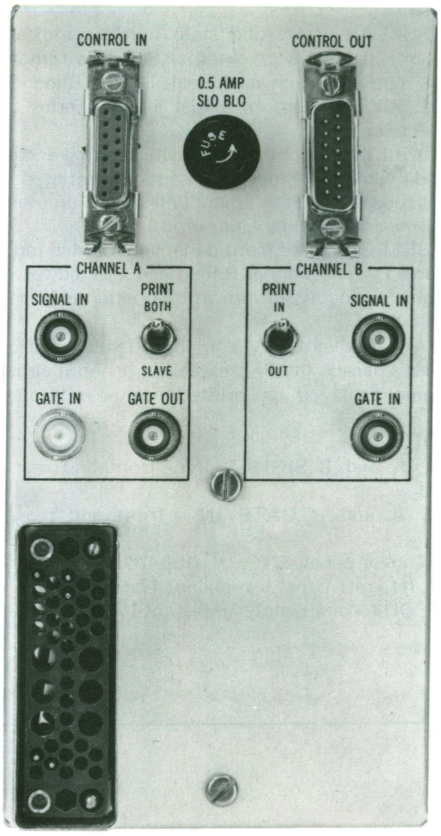
PRESET A MODE - toggle switch to select PRESET TIME or PRESET COUNT mode of operation for Channel A

PRESCALER - two toggle switches; one for each channel to enable (IN) or disable (OUT) an internal decade (÷10) prescaler

REAR PANEL CONTROLS

PRINT - Channel A; toggle switch to enable (BOTH) or enable (SLAVE) printout of the Channel A Master scaler with the Channel A Slave scaler

PRINT - Channel B; toggle switch to enable (PRINT) or inhibit (SKIP) printout of the Channel B scaler



INTERNAL CONTROLS

RECYCLE TIME - single-turn screwdriver potentiometer to vary time between recycles from 1 to 5 seconds; factory set for 1 second

RESET A - jumper plug to ENABLE or INHIBIT external electronic reset of Channel A Slave scaler; in INHIBIT position, Channel A Slave scaler can be reset to zero only by the front panel RESET pushbutton, factory set at ENABLE position

RESET B - jumper plug to ENABLE or INHIBIT external electronic reset of Channel B scaler; in INHIBIT position, Channel B scaler can be reset to zero only by the front panel RESET pushbutton; factory set at ENABLE position

DISC. A - single-turn screwdriver potentiometer selects threshold level for Channel A input signals; +0.5V to +10V range, factory set at +1.0V threshold level

DISC. B - single-turn screwdriver potentiometer selects threshold level for Channel B input signals; +0.5V to +10V range, factory set at +1.0V threshold level

PERFORMANCE

CAPACITY - three complete six decade scalers, all allowing full scale time range of 10^5-1 seconds or minutes, or full scale count range of 10^6-1 counts; Channel A Slave scaler and Channel B scaler are expandable to 10^7-1 counts or 10^6-1 seconds or minutes (A only) with front panel switch selectable decade (÷10) prescalers

COUNT RATE - 20MHz minimum (25MHz typical)

PULSE PAIR RESOLVING TIME - better than 50 nanoseconds (40 nanoseconds typical) for both channel signal inputs

TIME BASE ACCURACY - controlled by quartz crystal oscillator, accuracy of 0.002% over operating temperature range

TEMPERATURE OPERATING RANGE - 0 to 50°C

PRINTOUT SEQUENCE - Channel A Slave scaler, Channel A Master scaler, Channel B scaler

AUTOMATIC RESET - initiated when power is first turned on or after power failed; resets all decade counters to zero

Specifications(continued)

INDICATORS

VISUAL DISPLAY - six solid state numeric indicators; displays Channel A or Channel B or external Canberra remote blind Data Acquisition modules, such as Model 1476A Blind Scaler, Model 1490-1490C Blind Timer, or Model 1483A Series of Parallel to Serial Converters

COUNT - front panel light is illuminated during accumulation and extinguished when a Stop command is initiated or a preset condition is reached (COUNT light will remain on even though data accumulation is inhibited by Gate Input)

DISPLAY SELECT - three front panel lights which indicate whether Master Channel A or Channel B has been selected for visual display; all three lights extinguished indicates an external blind unit is being displayed

X10 - front panel light serves to indicate that the channel being displayed has a decade (÷10) prescaler in its input circuit; therefore, the data being displayed and printed must be multiplied by a factor of 10

CONNECTORS

CHANNEL A and B SIGNAL IN - front and rear panel, BNC, UG-1094/U

CHANNEL A and B GATE IN - front and rear panel, BNC, UG-1094/U

GATE OUT - rear panel, BNC, UG-1094/U

CONTROL IN - rear panel, Amphenol 17-10150

CONTROL OUT - rear panel, Amphenol 17-20150

POWER

+24V	— 0mA	+12V	— 250mA
- 24V	— 0mA	- 12V	— 90mA

115VAC — 230mA (AC power line protection via rear panel 0.5 amp SLO BLO fuse and holder)

PHYSICAL

SIZE - standard triple-width NIM module (4.05 x 8.71 inches) (10.29 x 22.13 cm) per TID-20893 (rev)

NET WEIGHT - 5.0 lbs. (2.27 kgs)

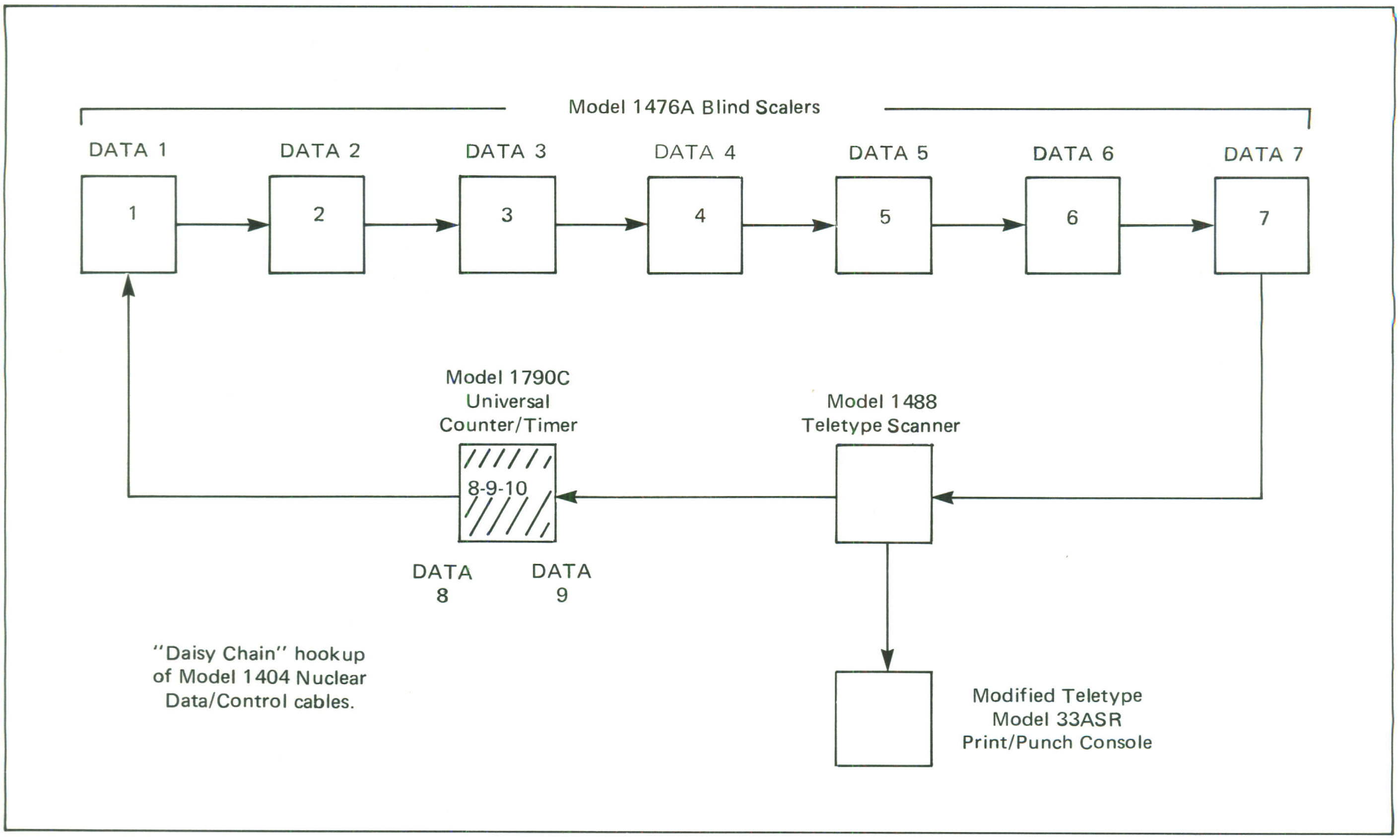
SHIPPING WEIGHT - 10 lbs. (4.54 kgs)

ACCESSORIES

One Canberra Model C-1404 Data/Control cable 2 ft. in length is supplied for connection to other Canberra Data Acquisition Series modules

TYPICAL APPLICATION

MULTIPLE CHANNEL BLIND SCALING SYSTEM - The Canberra Nuclear Data Acquisition System illustrated below provides an economical means of acquiring and recording a relatively large quantity of data from ten separate channels. This compact system requires only twelve NIM bin spaces... equal to one Canberra Model 2000 AEC Standard Bin/Power Supply. In a typical system setup, it provides a Master time base generator and ten blind slave scalers, all with display and printout capability.


Model 1476A Blind Scalers
DATA 1
DATA 2
DATA 3
DATA 4
DATA 5
DATA 6
DATA 7
1
2
3
4
5
6
7
Model 1790C
Universal
Counter/Timer
8-9-10
DATA 8
DATA 9
Model 1488
Teletype Scanner
"Daisy Chain" hookup
of Model 1404 Nuclear
Data/Control cables.
Modified Teletype
Model 33ASR
Print/Punch Console

Model 1795
Chronometer

Features

- Provides day of year and time of day
- Includes 2-digit tagword
- Buffered printout
- Marker output provides a logic pulse every second, minute, or hour
- Day's digits can be used to count:
    - Number of data acquisition cycles
    - Carries from HOURS for range of 0-99999 hours
    - Minutes: 0 to 999
    - Seconds: 0 to 999
- FLAG digit in printout allows external logic level to print a flag of 0 or 1.

Description

The Canberra Model 1795 Chronometer provides Day of Year and Time of Day information for incorporation into the data printout of Canberra data acquisition systems. In addition to chronological data, the Model 1795 also provides a 2-digit tagword and a 1-digit logic flag. The end result is a triple width module which allows the experimenter to readily incorporate real-world data into his data acquisition systems.

Large LED displays present the chronological data on the front panel. When the module is printed, the form is:

TTFDDD HHMMSS

TT : 2-digit tagword from front panel thumbwheel switches.

F : Flag digit 0 or 1 depending upon a logic level input BNC on the rear panel

DDD : 3-digit Day of Year, Range is 0 - 364 or 0 - 365 via an internal jumper. A rear panel switch changes these digits from Day of Year to data acquisition cycle number, with a range of 0-999.

HH : Hour of the Day.

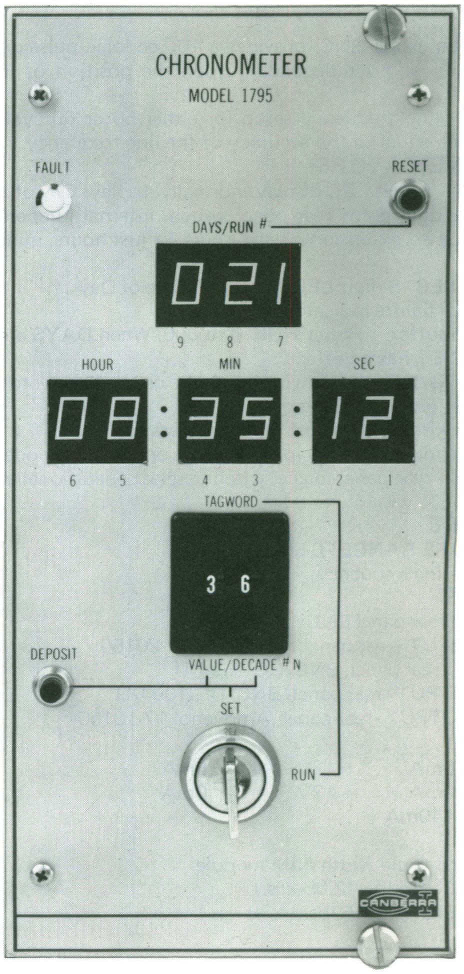
MM : Minute of the Hour.

SS : Second of the Minute.

In addition to providing the tagword, the 2-digit thumbwheel is also used to set the Model 1795 to the proper day and time. With the key-locked RUN/SET switch in the SET position, the digit position to be set is dialed into the right hand switch and the desired value into the left hand switch. Depressing the DEPOSIT pushbutton sets the value into the digit position.

The DAYS digits, when being used to count data acquisition cycles (rear panel switch selection), can be reset to 000 via the front panel RESET pushbutton. Note that the RESET button is disabled when these digits are being used for chronological purposes.

A front panel FAULT indicator is provided to warn the experimenter that a power failure has occurred, causing the time to be inaccurate. The fault indicator is cleared by placing the unit in SET.



Internal jumpers are provided to increase the flexibility of the Model 1795. Some of the jumper provisions are:

1. Suppressing the printout of the HHMMSS word.
2. Convert the DDD digits to:
    a. Count 0 - 999 days
    b. Extension of HOURS digits to 99999
    c. Count only hours
    d. Count only minutes
    e. Count only seconds
    (c, d, and e used when suppressing the printout of the HHMMSS word.)
3. Marker output interval selection (once per second, minute, or hour).
4. Time base selectable for 50 or 60Hz line frequency operation.

Specifications

INPUTS

CONTROL IN - rear panel input for Canberra "Daisy Chain" printout logic

FLAG - rear panel BNC input: if open or T^2L 1, the F digit will be a 0; if it is a T^2L O, the F digit will be a 1

TEST - rear panel BNC accepts 1MHz TTL pulse train to test the counting logic

OUTPUTS

CONTROL OUT - rear panel connector for Canberra "Daisy Chain" output

MARKER - rear panel BNC; provides a 10μsec logic pulse once per second, minute, or hour depending upon the position of internal jumpers

TIME BASE - line frequency setup for either 50 or 60 cycles; the accuracy will be equal to the accuracy of the line frequency.

CONTROLS/INDICATORS

DAYS/RUN #- 3-digit LED display: normally displays Day of Year or RUN # depending upon rear panel switch; internal jumpers allow DAYS to to be an extension of the hours, or just hours, minutes or seconds

HOUR: MIN: SEC - 6-digit LED display of Time of Day

FAULT - power failure indicator

RESET - pushbutton to reset RUN #to 000. When DAYS are being displayed, RESET has no effect.

TAGWORD - 2-digit thumbwheel switch; used as tagword (RUN mode) or to set clock (SET mode)

RUN/SET - locking switch to set mode of operation

DEPOSIT - pushbutton to set clock; operates only in SET mode

RUN #/DAYS - rear panel toggle switch to select operational mode of DAYS digits

PERFORMANCE

TEMPERATURE RANGE - 0-50°C

ACCURACY - line frequency

CONNECTORS

TEST INPUT - rear panel BNC, UG-1094/U

CONTROL INPUT - rear panel, Amphenol 17-20150

FLAG INPUT - rear panel, BNC, UG-1094/U

MARKER OUTPUT - rear panel, BNC, UG-1094/U

CONTROL OUTPUT - rear panel, Amphenol 17-10150

POWER

+24V — 0mA   +12V — 25mA
- 24V — 0mA   - 12V — 0mA
115VAC — 140mA

PHYSICAL

SIZE - standard triple-width NIM module

NET WEIGHT - 4.5 lbs. (2.05 kgs.)

SHIPPING WEIGHT - 9.5 lbs. (4.28 kgs.)

Model 2089
Serial Scanner/Printer

Features

- Ten digits per line (xxxx xxxxxx)
- Three lines per second print rate
- Prints up to 50 Canberra data acquisition modules
- Convenient internal or external print cycle control
- Two digit ID - thumbwheel controlled
- Three digit incrementing run counter
- Ink or pressure sensitive paper
- Leading zero suppression
- 42 word buffer optional

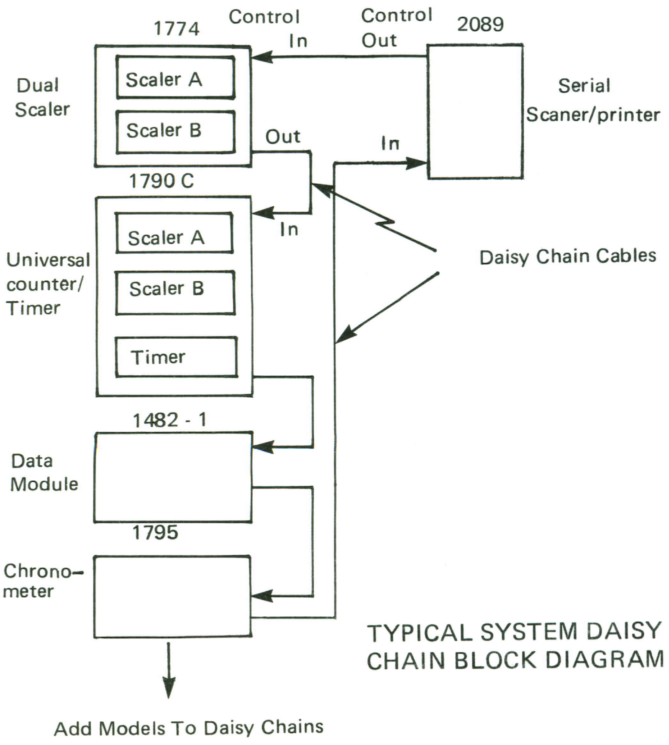
Description

The Canberra Model 2089 Serial Scanner/Printer automatically prints the data contained in up to 50 Canberra scalers, timers and other NIM data modules. The 2089 can also be used to print out the contents of Canberra's complete line of Multichannel Analyzers. Both NIM models and Multichannel Analyzers can be combined in a given system and output on the 2089. Standard adding machine or pressure sensitive tape may be used

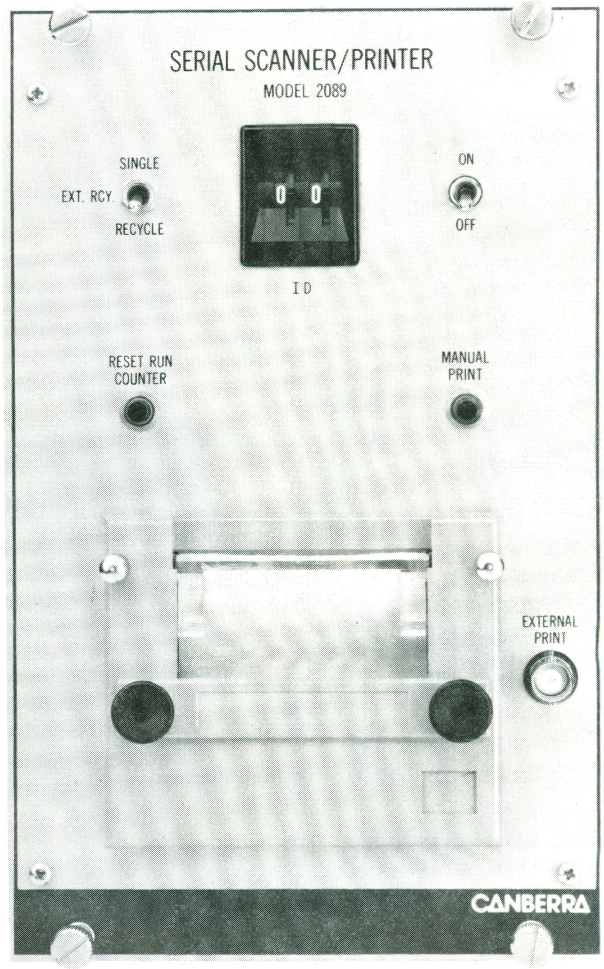
The print format is as follows:

The first line consists of two ID digits, a space and then three Run Counter digits. The Run Counter digits increment once at the beginning of each print cycle.

The remaining lines of a print cycle consist of a maximum of ten digits each. The first four digits indicate the line item while the last six digits are the contents of the particular scaler or memory location of the analyzer.


1774
Control In
Control Out
2089
Dual Scaler
Scaler A
Scaler B
Out
In
Serial Scaner/printer
1790 C
In
Universal counter/ Timer
Scaler A
Scaler B
Timer
Daisy Chain Cables
1482 - 1
Data Module
1795
Chrono-meter
Add Models To Daisy Chains

TYPICAL SYSTEM DAISY CHAIN BLOCK DIAGRAM


SERIAL SCANNER/PRINTER
MODEL 2089
SINGLE
EXT. RCY.
RECYCLE
0 0
ON
OFF
I D
RESET RUN COUNTER
MANUAL PRINT
EXTERNAL PRINT
CANBERRA

The Model 2089 connects the NIM components and analyzers in the system through Canberra's "Daisy Chain." Consequently units can be added at will in a serial fashion to the system.

System printing begins in response to a system stop signal from the Master (preset) Timer or scaler controlling system data accumulation. When the Model 2089 senses this signal, it assumes system control and sends data interrogation pulses down the system Daisy Chain cables. Each unit in turn sends back its accumulated data in 1-2-4-8 BCD bit parallel character serial format. The Model 2089 accepts each digit in turn and prints it onto the output tape. Standard format includes leading zero suppression.

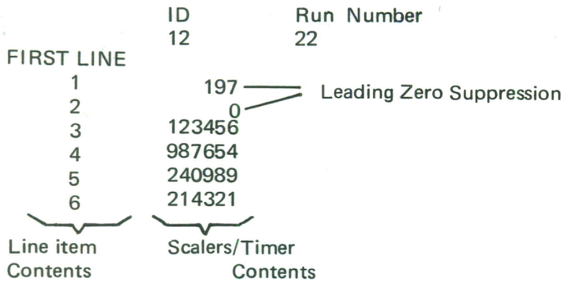
After all units have been printed, the Model 2089 may command the system master to reset and restart, which causes all the units in the system to reset and restart beginning another data cycle.

The Model 2089 has an Optional Data Buffer, which when installed, provides the capability of holding up to 42 words. It loads at 700 microseconds per word enabling the system to quickly go back into the data mode and collect more information.

Description (continued)

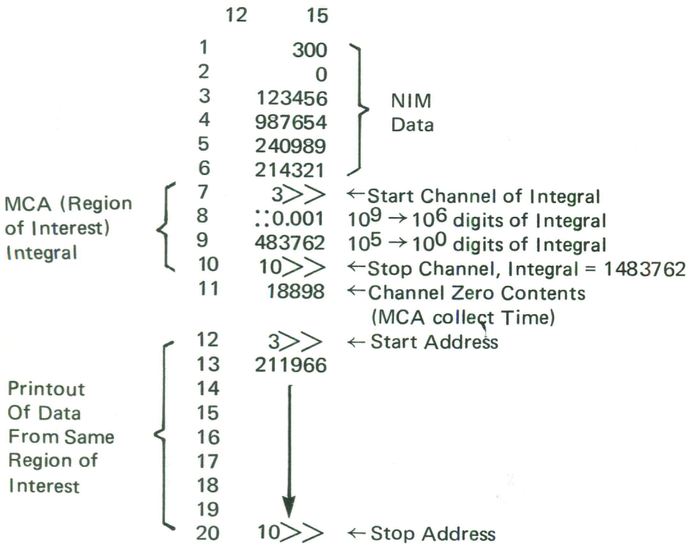
SAMPLE PRINTOUTS

EXAMPLE 1 NIM SYSTEM



```
               ID          Run  Number
               12          22
FIRST LINE
      1            197 ——  Leading Zero Suppression
      2              0 —
      3         123456
      4         987654
      5         240989
      6         214321
Line item       Scalers/Timer
Contents                Contents
```

EXAMPLE 2 NIM/MCA SYSTEM



```
                        12      15
                     1         300 }
                     2           0 }
                     3      123456 }  NIM
                     4      987654 }  Data
                     5      240989 }
                     6      214321 }
MCA (Region        { 7         3>>   ←Start Channel of Integral
of Interest)       { 8     ::0.001   10^9 → 10^6 digits of Integral
Integral           { 9      483762   10^5 → 10^0 digits of Integral
                   { 10       10>>   ←Stop Channel, Integral = 1483762
                     11      18898   ←Channel Zero Contents
                                       (MCA collect Time)
                   { 12        3>>   ← Start Address
                   { 13     211966
Printout           { 14       |
Of Data            { 15       |
From Same          { 16       |
Region of          { 17       |
Interest           { 18       |
                   { 19       ↓
                   { 20       10>>   ← Stop Address
```

Specifications

INPUTS

CONTROL INPUT - 15 pin connector accepts EOM/STOP, system STOP and 1-2-4-8 BCD data in bit parallel, character serial data format; logical 1 = +4 +5 volts, logical 0 = 0 to +0.5 volts. EOM/STOP system STOP must be a five volt negative step from a +5 volt level; maximum rise time 500 nanoseconds, minimum width 1 microsec. DC coupled; rear panel Amphenol 17-10150 connector.

EXTERNAL PRINT - +4 to +10 volt pulse causes the system to STOP and printout to begin; maximum rise time 500 nanoseconds, minimum width 100 nanoseconds; DC coupled; front panel BNC connector.

RECYCLE TIMER - accepts pulse which causes counting system to recycle; 5 volt negative-going pulses from +5 volt level, maximum rise time 500 nanoseconds, minimum width 1 microsec; DC coupled; rear panel Amphenol 17-20150 connector.

OUTPUTS

CONTROL OUTPUT - 15 pin connector provides PRINT CLOCK, HOLD, STOP, RESET, and START commands to the system. Commands are five volt negative-going pulses from +5 volt DC level, rise times less than 500 nanoseconds, HOLD is a level with logic 1 = 0 to +0.5V and logic 0 = +2.5 to 5.0V. START, STOP and RESET commands have pulse widths of 1 microsecond minimum. PRINT CLOCK pulse width in 3 microseconds minimum. DC coupled; rear panel Amphenol 17-20150.

BUSY - voltage level on rear panel BNC connector +2.5 to +5.0 volts until the 2089 has transferred the data from all the modules in the system. Zero to 0.5 volts indicates the 2089 does not require data from the system modules.

CONTROLS

ON/OFF - front panel toggle switch enables or inhibits the Model 2089 from printing; the data system connected to the Serial Scanner Printer is not affected by this switch.

MANUAL PRINT - front panel pushbutton, when depressed, causes data system to stop and printout to occur.

SINGLE/RECYCLE - front panel toggle switch; SINGLE position causes entire data system to hold without resetting after printout until manually reset and restarted, RECYCLE position permits automatic system reset and restart after printout; useful principally for system checkout; EXTERNAL RECYCLE position permits a timed interval between successive system accumulation cycles, using an auxiliary Model 1490 Timer connected to the Recycle Timer input.

RESET RUN COUNTER - front panel pushbutton, when depressed, causes the three digit Internal Run Counter to be reset to zero.

ID - front panel two digit thumbwheel switch provides, in combination with the internal Run Counter, a first word printed consisting of a two digit ID, a space, and then the three digit run counter contents. The ID (two digits) is determined by the thumbwheel switches.

OPTION 01 - BUFFER

Capacity: 42, 6 digit words
Loading Rate: 1400 words per second
Load Time: 42 words, 30 milliseconds

PERFORMANCE:

Temperature: 0 to 50°C
Humidity: to 95% (non-condensing)
Printing Rate: Three lines per second
Print Capacity: 72 lines per foot of tape; 97 feet per roll
Character Size: 7 x 5 Dot Matrix 0.11" H x 0.08"W.
Line Spacing: 6 per inch
Line Counter: four digit number printed on each data line to identify data word
Zero Suppression: All numbers are printed with most significant zeroes suppressed

CONNECTORS

CONTROL INPUT - rear Amphenol 17-10150
CONTROL OUTPUT - rear Amphenol 17-20150
EXTERNAL RECYCLE INPUT - rear Amphenol 17-20150
BUSY - rear BNC
EXTERNAL PRINT - Front BNC

POWER

105 to 125 VAC 50-60 Hz
Optional connections provided 95 to 115
190 to 230
210 to 250
14 watts Non-printing
Approximately 35 watts Printing

PHYSICAL

SIZE - standard four-width module (5.4 inches wide) (13.23 cm wide) per TID 20893
NET WEIGHT - 9.5 lbs (4.28 kgs)
SHIPPING WEIGHT - 15 lbs. (6.75 kgs.)

ACCESSORIES

Included with the 2089 are the following: 1 Canberra Model 1404 Data/Control cable 2 ft. in length for connection to other Canberra Data Acquisition Series NIM modules.

1 Ink Cartridge
1 Roll standard paper
1 Metal Platen
1 Roll pressure sensitive paper

POWER SUPPLY INTRODUCTION

To insure the user of the ultimate performance of his system, Canberra has redesigned and enlarged its family of detector Power Supplies. For each application there is a correct supply which offers the maximum in performance with economy in price. It is no longer necessary to settle for or pay for a power supply that has more power and features than necessary. From our family of supplies you can choose the exact supply for your particular application.

Model 3102 – A 0 to ± 2000VDC, 2mA low noise, single-width NIM bias supply designed for use with Silicon Surface Barrier, Si(Li), Gas Proportional and Scintillation Photomultiplier Tube Detectors. The 2mA output is sufficient to bias two photomultiplier tubes.

Model 3002 – A 0 to ± 3000VDC, 10mA double-width NIM bias supply offering the user a good general purpose high current supply. The 3002 is powered by 110VAC allowing the unit to be operated in or out of the NIM bin. The 10mA output is ideal for biasing up to ten photomultiplier tube bases.

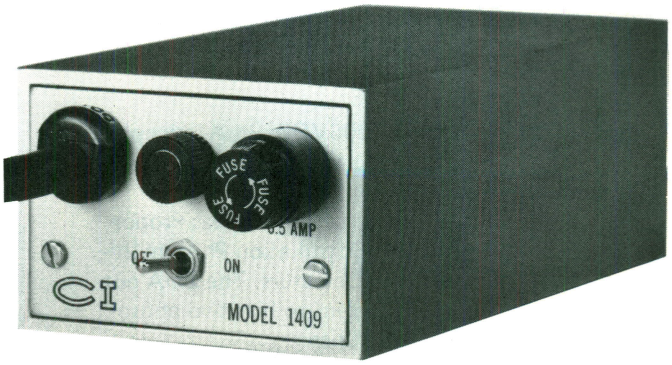
Model 3105 – A 0 to ± 5000VDC, 100μA, low noise, single-width NIM bias supply designed for use with Ge(Li) and HPGE detectors. For proportional detectors requiring over 2kV bias, the 3105 is also ideal.

Model 3005R – A 0 to ± 5000VDC, 100μA 19" wide rack mount bias supply. For the user whose system does not have a NIM bin, the 3105R is the answer. It saves the added cost of purchasing a NIM bin specifically for the bias supply in Ge(Li) detector systems, with the Series 80 or 8100 Multichannel Analyzers.

Model 4162 – A 0 to ± 5000VDC, 100μA low noise bias supply designed for use with Ge(Li) and HPGE detectors, and proportional counters where more than 2 kv is required. This unit is designed as a bolt-on addition to the Series 40 for those instances where a NIM BIN slot is not available.

MODEL	BIAS	CURRENT	APPLICATION	SPACE
3102	±2kV	2mA	NaI, Surface Barrier, Gas Proportional, Si(Li)	1 Width
3002	±3kV	10mA	NaI, Gas Proportional Si(Li), Ge(Li)	2 Widths
3105	±5kV	100μA	Ge(Li), HPGE	1 Width
3005R	±5kV	100μA	Ge(Li), HPGE, NaI, Gas Proportional, Si(Li)	19" Rack
4162	±5kV	100 μA	Ge(Li), HPGE	1 Width

Model 1409
Preamplifier Power Supply



Features

- Uses 115 or 230VAC (option) input power
- Provides ±24VDC, ±12VDC, all at 40mA
- Less than 4.5mV RMS ripple and noise
- Regulation better than ±1%

Description

The Canberra Model 1409 Preamplifier Power Supply provides the necessary DC operating voltages for any preamplifiers in the Canberra 800, 900, 1400 and 2000 Series in the four voltages recommended in AEC Report TID-20893: +24V, - 24V, +12V, - 12V.

In turn, the Model 1409 requires only a 115 (230 option) volt AC, 50-60Hz source of power. The Model 1409 offers a load regulation better than ±1% for a 10% change in the nominal AC line voltage.

The Preamplifier Power Supply can provide up to 40mA at each of the output voltages, sufficient to power any commercially available transistorized preamplifier requiring the recommended voltages. Preamplifier supply voltages are available through an Amphenol 17-10090 connector, which mates with the power cable supplied with each Canberra 800, 900, 1400, or 2000 Series preamplifier

Specifications

INPUTS

AC POWER - 115VAC (230VAC optional) ±10%, 50-60Hz; through 3-wire cord with standard NEMA plug.

OUTPUTS

+24VDC	—	40mA	+12VDC	—	40mA
- 24VDC	—	40mA	- 12VDC	—	40mA

Supplied through Amphenol 17-10090.

PERFORMANCE

LOAD REGULATION - less than ±0.5%, no load to 20mA; ±1%, no load to full load (40mA).

LINE REGULATION - less than ±1% output voltage change for a 10% change in the nominal AC line voltage.

RIPPLE AND NOISE - less than 12mV peak-to-peak, less than 4.5mV RMS.

CONTROLS/INDICATORS

A Power ON/OFF toggle switch and indicator light are included with the power supply.

CONNECTORS

PREAMP POWER - Amphenol 17-10090 connector (mates with Model 1402 Preamp Power Cable supplied with 800, 900, 1400 and 2000 Series preamplifiers).

AC LINE CORD - 3-wire with standard NEMA plug.

PHYSICAL

SIZE - 6" x 3" x 1.5"; (15.2 x 7.6 x 3.8 cm) extruded aluminum case.

NET WEIGHT - 2.8 lbs. (1.3 kgs).

SHIPPING WEIGHT - 4.0 lbs. (1.8 kgs).

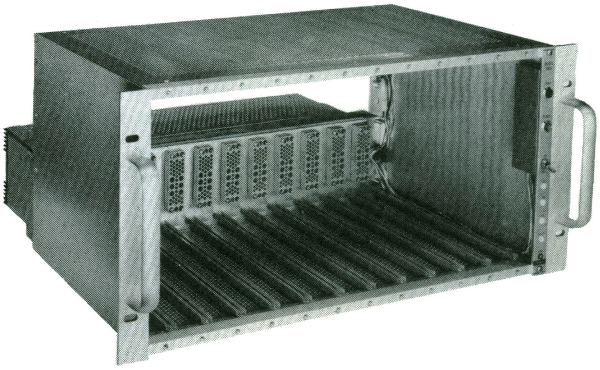
OPTIONS

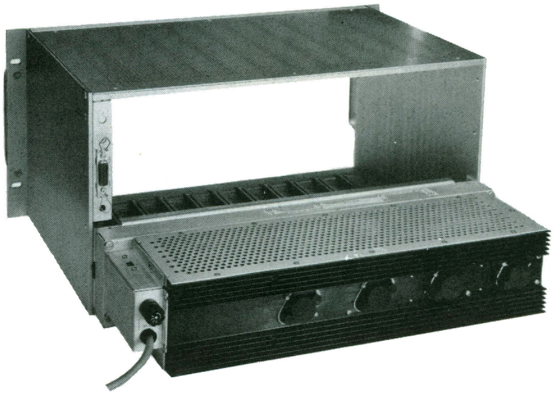
The Model 1409 can be supplied for 230VAC ±10% single phase, 50Hz operation.

Model 2000 Bin/Power Supply

Features

- NIM standard
- 96 Watt output
- 115V/220V operation
- Short circuit protection
- Thermal protection
- Slave connector





Description

The Canberra Model 2000 Bin/Power Supply provides mounting space and power sources for up to 12 standard Nuclear Instrument Modules (NIM's) of the 8-3/4" high type, conforming to the recommended standards of USAEC report TID-20893 (rev.) Multiple width NIM modules are also accommodated in any combination up to a total of 12 equivalent module widths.

Rear connector plugs for each module position are wired to provide the standard power supply voltages of ±6.00, ±12.00 and ±24.00VDC, and also provide a nominal 117VAC single phase line isolated from the bin chassis. The self-contained power supply complies with the characteristic requirements of a Type 1, Class A supply, providing the ±12.00 and ±24.00VDC regulated outputs, and the nominal 117VAC line. Protection features include electronic short circuit protection on the regulated outputs (instant reset), thermal warning indicator and thermal cutouts, and an AC line fuse.

The control panel includes an ON-OFF switch, a power monitor lamp, and a temperature warning lamp which indicates temperatures approaching the design limit of the power supply.

An accessory connector (Amphenol Model 17-10150) is brought out on the rear of the bin to provide supply voltages for the Model 2000A Slave Bin, to power preamplifiers that use the standard voltages, or to give a ready means of inserting ±6 volt supply voltages from an optional rack mounted power supply.

A switch on the rear power supply chassis allows selection of input power from either 115VAC (nominal), or 230VAC (nominal).

Specifications

INPUTS

INPUT VOLTAGE - 100 to 130 VAC, or 200 to 260 VAC (switch selected), frequency range 45 to 65Hz, sinusoidal single phase

OUTPUTS

REGULATED DC 96 WATT OUTPUT AS FOLLOWS:

+12.00VDC	—	2 Amp maximum
- 12.00VDC	—	2 Amp maximum
+24.00VDC	—	1 Amp maximum
- 24.00VDC	—	1 Amp maximum

All DC outputs are available simultaneously at maximum indicated current rating, at an ambient temperature of up to +50°C. Total output power is derated 3%/°C up to a maximum rated ambient of +60°C.

UNREGULATED AC - 117V nominal, 0.5A maximum

TEST POINTS - the four regulated voltages and power ground are brought out to front panel jacks for test purposes

PERFORMANCE

REGULATION/STABILITY - after a 60 minute warmup with constant ambient temperature, the output voltages will not vary more than ±0.05% during any 24 hour period for maximum line and load changes

TEMPERATURE COEFFICIENT - less than ±0.01%/°C (±100ppm/°C); operating range from 0°C to 60°C

NOISE AND RIPPLE - less than 3mV peak to peak (50MHz bandwidth)

OVERLOAD PROTECTION - electronic protection for overloads above 120% of rated output current (automatic recovery)

TRANSIENT RESPONSE TIME - 50 microseconds for recovery to within ±0.1% of the output voltage for any line change within rated limits or a 10% - 100% load change

CONTROLS

THERMAL OVERLOAD - internal switch disables power when temperature limit is exceeded. A red warning lamp indicates when the temperature design limit is approached

VOLTAGE ADJUSTMENT - regulated outputs are individually adjustable over a range of at least ±0.5%, with a resetability within ±0.05%, by means of trimming potentiometers accessible thru the top cover of power supply

ON-OFF CONTROL - ON-OFF switch to control power. An amber indicator light signals power ON condition

PHYSICAL

MODULE CONNECTORS - 12 each AMP type 202516-3

ACCESSORY POWER CONNECTOR - an optional cable is available so that the Model 2000 Bin and Power Supply can be made to power a Model 2000A Bin (without power supply); Amphenol type 17-10150-1

SERVICEABILITY - regulators for the four voltages are located on separate plug-in printed circuit cards readily accessible from the rear of the power supply; in case of trouble any one of the voltage regulator cards can easily be replaced

SIZE - conforms to AEC Report TID-20893; dimensions: (19.0 x 8.7 x 17.5 inches deep) (48.26 cm x 22.10 cm x 44.45 cm)

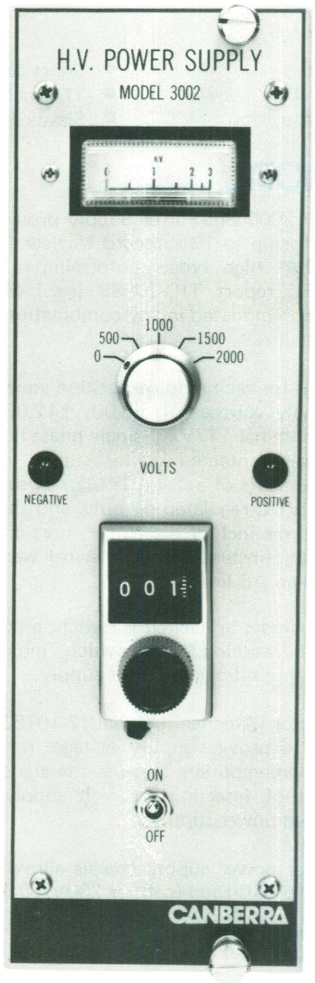
NET WEIGHT - 21 lbs. (9.5 kgs)

SHIPPING WEIGHT - 25 lbs (11.3 kgs)

Model 3002
High Voltage Power Supply

Features

- Compact double-width NIM package
- Regulated ±0-3000VDC, 0-10mA output
- External control of output voltage over full range
- Front panel lights indicate polarity
- Noise and ripple <10mV P-P — no audible noise
- 115 or 230VAC input power
- Overload and short-circuit protected
- Meter to monitor output voltage



Description

The Canberra Model 3002 is a NIM-bin compatible high voltage power supply designed for operation with essentially all types of nuclear radiation detectors. Particularly well suited to high resolution system applications, the standard double-width NIM module supplies a highly regulated detector bias with extremely low ripple and noise content.

A recessed switch on the bottom panel is used to select either 115 or 230VAC input power furnished through a power line cord and connector. The Model 3002 can also be operated outside the NIM bin from any AC power receptacle, since it requires no power from the bin. The unit has no audible noise; therefore, it can be operated in close proximity to users without the effects of irritating, unpleasant audio sounds. The power supply will withstand any overload or direct output short-circuit for an indefinite period of time and provide normal output automatically upon removal of the overload.

Output voltage is continuously adjustable by means of the two calibrated front panel voltage controls over the full range from 0 to ±3000 volts. The output voltage can also be controlled over its full range by application of an external input DC level of 0 to - 5V through a rear panel BNC connector. This feature is desirable for control applications and is standard on all units. A meter is provided to monitor the output voltage.

A polarity reversal switch provides selection of positive or negative output polarity. To prevent inadvertent polarity reversal, the switch is top panel mounted and screwdriver activated. In addition, the setting of the polarity selector switch is indicated by illumination of either the positive or negative LED indicator on the front panel for safety and convenience of the user.

Specifications

INPUTS

AC POWER LINE - 115/230VAC ±10%, 50-60Hz; power supplied through rear panel 3-wire captive line cord with standard NEMA male connector

PROGRAM (REMOTE) - accepts external reference input to determine output voltage when PROGRAM switch is in REMOTE; 0 to - 5 volt input provides 0 to ±3000VDC output, rear panel BNC connector; the output polarity is set by the polarity selector switch

OUTPUTS

REGULATED H.V. OUTPUT - 0 to ±3000VDC, continuously adjustable; 0 to 10mA output current capability; two rear panel SHV high voltage coaxial connectors

CONTROLS

POWER - front panel 2 position toggle switch for main AC power input

OUTPUT VOLTAGE - two front panel controls to set output amplitude when rear panel program switch is set in the local position; 0-2000V in 500V steps; 0-1000V with 10-turn locking precision potentiometer; output voltage is sum of the two control settings ±0.25%

PROGRAM LOCAL/REMOTE - rear panel slide switch selects LOCAL (manual) operation or REMOTE reference input to determine output voltage

POLARITY - rear panel 2 position screwdriver switch selects either POSitive or NEGative output polarity

115/230 VAC - recessed slide switch on the bottom panel permits operation on either 115 or 230VAC nominal input power

INDICATORS

METER - output voltage monitor

LED LAMPS - polarity (positive and negative)

Specifications(continued)

PERFORMANCE

RIPPLE AND NOISE - <10mV peak-to-peak, 5Hz to 50MHz

OUTPUT STABILITY - long term drift of output voltage is <0.01%/hr. and <0.02%/8 hr. period, at constant input line voltage, load, and ambient temperature, after a 30 minute warmup

REGULATION - ⩽0.001% variation in output voltage for line changes; ⩽0.01% variation in output voltage for load changes within the operating range at constant ambient temperature

TEMPERATURE COEFFICIENT - ⩽±50ppm/°C after 30 minute warmup, operating range 0 to 50°C

OVERLOAD PROTECTION - power supply will withstand any overload, including a short-circuit for an indefinite period, and will automatically resume normal operation upon removal of the overload

CALIBRATION ACCURACY - output voltage will differ by <±0.25% from sum of control settings plus 0.05% of maximum voltage

RESETABILITY - output voltage can be reset to within ±0.2 volt

OUTPUT LOAD CAPACITY - 0 to 10mA

OUTPUT RANGE - 0 to ±3000VDC

CONNECTORS

INPUT POWER - rear panel 3-wire captive AC line cord with standard NEMA male connector

OUTPUT VOLTAGE - two rear panel type SHV high voltage coaxial connectors

REMOTE CONTROL - rear panel, BNC

POWER REQUIREMENTS

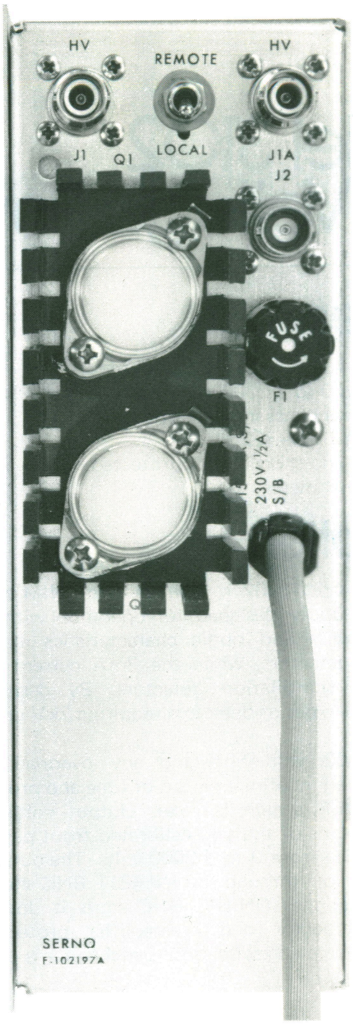
115/230VAC, 50-60Hz, no DC power requirements; AC power line protection via rear panel 1 amp SLO BLO fuse (0.5 amp SLO BLO for 230VAC)

PHYSICAL

SIZE - standard double-width NIM module (2.70 x 8.71 inches) (6.85 x 22.13 cm) per TID-20893 (rev.).

NET WEIGHT - 11 lbs. (5.0 kgs)

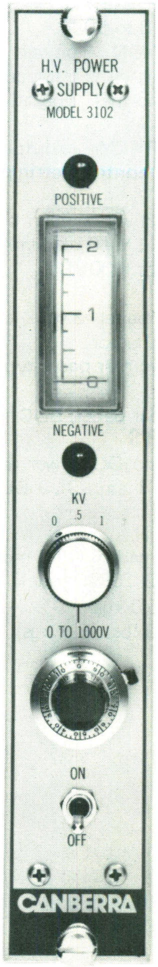
SHIPPING WEIGHT - 13 lbs. (5.9 kgs)



Model 3102
High Voltage Power Supply

Features

- Compact single-width NIM package
- Regulated 0 to ±2000VDC, 2mA output
- Front panel lights indicate polarity
- Noise and ripple <2mV P-P
- Overload and short circuit protected
- Front panel meter



Description

The Canberra Model 3102 is a single width NIM bin compatible high voltage power supply designed for operation with a wide variety of detectors. Its noise and ripple characteristics make it suitable for surface barrier detectors, while the 2mA current capability permits operation with scintillation detectors. By design, the 3102 will accommodate all types of detectors requiring 2kV or less.

The Model 3102 will withstand any overload or direct output short-circuit for an indefinite period of time and provide normal output after the ON-OFF switch is reset. Output voltage is continuously adjustable by means of the two calibrated front panel voltage controls over the full range from 0 to ±2000 volts. The output voltage can also be turned on or off through the INHIBIT BNC shutdown on the rear panel. Grounding the INHIBIT BNC shuts it down. This feature is desirable for detector and preamplifier protection is numerous applications. A large edgewise front panel meter is provided to monitor the output voltage.

A polarity reversal connector provides selection of positive or negative output polarity. To prevent inadvertent polarity reversal, the connector is located inside the module. The polarity is indicated by illumination of either the positive or negative LED on the front panel for the safety and convenience of the user.

Specifications

INPUTS

INPUT POWER - The Model 3102 is powered from a standard NIM bin and power supply, such as the Model 2000.

OUTPUTS

REGULATED HIGH VOLTAGE - 0 to ±2000VDC, continuously adjustable; 0 to 2mA output current capability; one rear panel SHV high voltage coaxial connector.

CONTROLS

ON-OFF - front panel 2 position toggle switch to enable or disable output.

OUTPUT VOLTAGE - two front panel controls to set output amplitude; 0 to 1000 volts in 500 volt steps with the coarse control and 0 to 1000 volts via a 10-turn precision potentiometer. The nominal output is the sum of the two settings.

POLARITY - internal connector changes output polarity by reversing orientation.

INHIBIT - rear panel BNC to turn off the high voltage. Short circuit turns it off. Open circuit resumes output.

INDICATORS

OUTPUT VOLTAGE - edgewise output voltage meter.

POLARITY - front panel LED indicator lights for positive or negative polarity.

PERFORMANCE

RIPPLE AND NOISE - $\leqslant$2mV peak to peak.

OUTPUT STABILITY - long term drift of output voltage is $\leqslant$0.01%/hr. and $\leqslant$0.02%/8 hr. at constant input line voltage, load, and ambient temperature after a 30 minute warmup.

REGULATION - $\leqslant$0.001% variation in output voltages for line and load changes within the operating range at constant ambient temperature.

TEMPERATURE COEFFICIENT - $\leqslant \pm 50$ppm/C^{o} after 30 minute warmup, operating range 0 to 50^{o}C.

OVERLOAD PROTECTION - power supply will withstand any overload, including a short circuit for an indefinite period, and will resume normal operation after manual reset.

CALIBRATION ACCURACY - ±0.5% of dial setting +0.25% full scale.

RESETABILITY - output voltage can be reset to within 1 volt.

OUTPUT LOAD CAPACITY - 0 to 2mA.

OUTPUT RANGE - 0 to ±2000VDC.

CONNECTORS

OUTPUT VOLTAGE - rear panel SHV

GATE - rear panel BNC

POWER REQUIREMENTS

+24V	—	83mA	+12V	—	50mA
- 24V	—	83mA	- 12V	—	50mA

PHYSICAL

SIZE - standard single width NIM module (1.35 x 8.71 inches), (3.42 cm x 22.13 cm) per TID-10893 (rev.)

NET WEIGHT - 3.8 lbs. (1.7 kgs)

SHIPPING WEIGHT - 6.0 lbs. (2.7 kgs)

Model 3105
High Voltage Power Supply

H.V. POWER
SUPPLY
MODEL 3105
POSITIVE
5
4
3
2
1
0
NEGATIVE
0 TO 5000V
ON
OFF
CANBERRA

Features

- Compact 1 wide NIM package
- Regulated 0 to ±5000VDC, 0 to 100μA output
- Front panel lights indicate polarity
- Noise and ripple <3mV peak to peak
- Overload and short circuit protected
- Front panel meter

Description

The Canberra Model 3105 is a NIM high voltage power supply designed primarily for operation with semiconductor detectors. It is particularly well suited for use with high resolution detector systems. By design, the 3105 will accommodate all types of detectors requiring up to 5kV bias and up to 100μA of current.

The 3105 will withstand any overload or direct output short-circuit for an indefinite period of time and provide normal output after the ON-OFF switch is reset. Output voltage is continuously adjustable over the full range from 0 to ±5000 volts by means of a five turn control. The output voltage can also be turned on or off through the INHIBIT BNC on the rear panel. Grounding the INHIBIT BNC shuts it down. This feature is desirable for detector and preamplifier protection in numerous applications. A large edgewise front panel meter is provided to monitor the output voltage.

A polarity reversal connector provides selection of positive or negative output polarity. To prevent inadvertent polarity reversal, the connector is located inside the module. In addition, the setting of the polarity connector is indicated by illumination of either the positive or negative LED on the front panel for the safety and convenience of the user.

Specifications

INPUTS

INPUT POWER - the Model 3105 is powered from a standard NIM bin and power supply, such as the Model 2000

OUTPUTS

REGULATED HIGH VOLTAGE - 0 to ±5000VDC, continuously adjustable; 0 to 100μA output current capability; one rear panel SHV high voltage coaxial connector

CONTROLS

ON-OFF - front panel 2 position toggle switch to enable or disable output

OUTPUT VOLTAGE - front panel 5-turn direct readout dial permits continuous adjustment of the output voltage, ±0 to 5000VDC

POLARITY - Internal connector changes output polarity by reversing orientation

INHIBIT - rear panel BNC to turn off the high voltage. Short circuit turns it off. Open circuit resumes output

INDICATORS

OUTPUT VOLTAGE - edgewise output voltage meter

POLARITY - front panel LED indicator lights for positive or negative polarity

PERFORMANCE

RIPPLE AND NOISE - ≤3mV peak to peak

OUTPUT STABILITY - long term drift of output voltage is ≤0.01%/hr. and ≤0.02%/8 hr. at constant input line voltage, load, and ambient temperature after a 30 minute warmup

REGULATION - ≤0.001% variation in output voltages for line and load changes within the operating range at constant ambient temperature

TEMPERATURE COEFFICIENT - ≤±50ppm/°C after 30 minute warmup, operating range 0 to 50°C

OVERLOAD PROTECTION - power supply will withstand any overload, including a short circuit for an indefinite period, and will resume normal operation after manual reset

CALIBRATION ACCURACY - ±0.5% of dial setting +0.25% of full scale

RESETABILITY - output voltage can be reset to within 10 volts

OUTPUT LOAD CAPACITY - 0 to 100μA

OUTPUT RANGE - 0 to ±5000VDC

CONNECTORS

OUTPUT VOLTAGE - rear panel SHV

GATE - rear panel BNC

POWER REQUIREMENTS

+24V	—	83mA	+12V	—	50mA
- 24V	—	83mA	- 12V	—	50mA

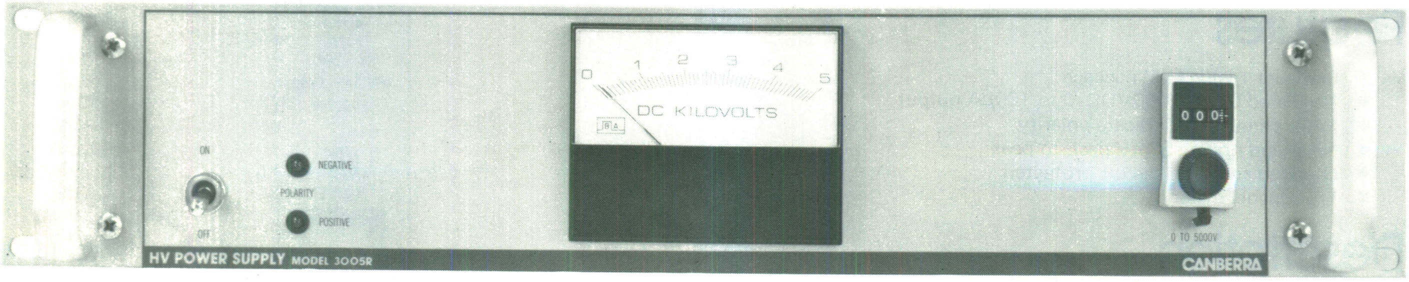
PHYSICAL

SIZE - standard single width NIM module (1.35 x 8.71 inches) (3.42 x 22.13 cm) per TID-10893 (rev)

NET WEIGHT - 3.5 lbs. (1.6 kgs)

SHIPPING WEIGHT - 6.0 lbs. (2.7 kgs)

Model 3005R High Voltage Power Supply



Features

- Rack or bench mounted package
- Regulated 0 to ±5000VDC, 0 to 1mA output
- Front panel lights indicate polarity
- Noise and ripple <10mV P-P
- Overload and short circuit protected
- Large front panel meter

Description

The Canberra Model 3005R is a rack or bench mounted high voltage power supply designed for operation with semiconductor or gas proportional counter detectors requiring up to ±5000VDC bias. Particularly well suited to high resolution system applications because of its low ripple output, this unit will find use in the laboratory for experiments with most any modern detector type.

The output voltage of the Model 3005R is continuously adjustable over the full range from 0 to ±5000VDC by means of a 5-turn precision counter type control. Output current capability is up to 1mA continuous at any output voltage. The output voltage can be switched off or on through a rear panel INHIBIT connector. Grounding this BNC type connector shuts the unit down. This feature is desirable for detector and preamplifier protection in numerous applications.

A large front panel meter monitors the output voltage of the unit. The voltage polarity is selected by a rear panel screwdriver control switch, and indicated on the front panel by illumination of either a POSITIVE or NEGATIVE indicator LED for safety and convenience of the user.

Input power for the Model 3005R is drawn from either 115V or 230VAC through a power line cord and connector. A recessed switch on the rear panel is used to select either input voltage level. The power supply will withstand any overload or direct output short circuit for an indefinite period of time, and provide normal output automatically upon removal of the overload. The unit has no audible noise and can therefore be operated close to users without irritating, unpleasant audio noise.

Specifications

INPUTS

AC POWER LINE - 115/230VAC ±10%, 50-60Hz sinusoidal single phase; power supplied through rear panel 3-wire captive line cord with standard NEMA connector.

OUTPUTS

REGULATED HIGH VOLTAGE - 0 to ±5000VDC, continuously adjustable; 0 - 1mA output current capability; 2 rear panel SHV high voltage coaxial connectors.

CONTROLS

ON/OFF - front panel 2 position toggle switch to enable or disable unit by switching AC line power.

OUTPUT VOLTAGE - front panel 5-turn counter readout control permits continuous adjustment of the output voltage from 0 to ±5000VDC.

POLARITY - rear panel screwdriver activated switch selects either POSITIVE or NEGATIVE output voltage polarity.

INHIBIT - rear panel BNC to gate off the high voltage output; short circuit reduces output to 0, open circuit resumes preset output.

INDICATORS

OUTPUT VOLTAGE - large meter displays actual output voltage.

POLARITY - front panel LED indicator lights for POSITIVE or NEGATIVE output voltage polarity.

PERFORMANCE

RIPPLE AND NOISE - ≤3mV peak to peak at 100μA output, and ≤10mV peak to peak at 1mA output.

OUTPUT STABILITY - long term drift of output is ≤0.01%/hr. and ≤0.02%/8 hr. at constant input line voltage and load, and ambient temperature after a 30 minute warmup.

REGULATION - ≤0.01% variation in output voltage for line voltage, and ≤0.01% variation for load changes within the operating range at constant ambient temperature.

TEMPERATURE COEFFICIENT - ≤±50ppm/°C after 30 minute warmup, operating rangs 0 to 50°C.

OVERLOAD PROTECTION - power supply will withstand any overload, including a short circuit for an indefinite period, and will recover to normal operation upon removal of the overload.

CALIBRATION ACCURACY - ±0.25% of dial setting + 0.05% of full scale.

RESETABILITY - output voltage can be reset to within 5 volts.

OUTPUT LOAD CAPACITY - 0 to 1mA.

OUTPUT RANGE - 0 to ±5000VDC.

CONNECTORS

OUTPUT VOLTAGE - 2 rear panel mounted SHV.

INHIBIT - rear panel mounted BNC.

POWER REQUIREMENTS

115/230VAC, 50-60Hz, sinusoidal single phase; no DC requirements; AC power line protection via rear panel 0.5 amp SLO BLO fuse (0.25 amp SLO BLO fuse for 230V)

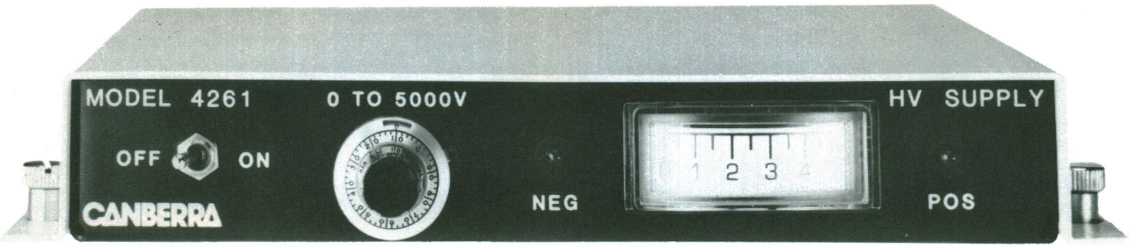
PHYSICAL

SIZE - 19" wide (rack mount) x 3-1/2" high x 10" deep (48.3 x 8.9 x 25.4 cm)

NET WEIGHT - 8.7 lbs. (4.0 kgs).

SHIPPING WEIGHT - 11 lbs. (5.0 kgs).

Model 4261
High Voltage Bias Supply



Features

- Compact package
- Regulated 0 to ± 5000 VDC, 0 to 100μA output
- Front panel lights indicate polarity
- Ripple < 2mV peak to peak
- Overload and short circuit protected
- Front panel meter
- Bolts onto Series 40 MCA

Description

The Canberra model 4261 is a high voltage power supply designed as an accessory for the Series 40 multichannel analyzer, and was designed primarily for operation with semiconductor detectors. It is particularly well suited for use with high resolution detector systems. By design, the 4261 will accommodate all types of detectors requiring up to 5 KV bias and up to 100μA of current.

The 4261 will withstand any overload or direct output short-circuit for an indefinite period of time and provide normal output after the ON-OFF Switch is reset. Output voltage is continuously adjustable over the full range from 0 to ± 5000 volts by means of a single turn control. The output voltage can also be turned on or off through the GATE BNC on the rear panel. Grounding the GATE BNC shuts it down. This feature is desirable for detector and preamplifier protection in numerous applications. A large edgewise front panel meter is provided to monitor the output voltage.

A polarity reversal switch provides selection of positive or negative output polarity. To prevent inadvertent polarity reversal, the switch is located inside the module. In addition, the setting of the polarity selector switch is indicated by illumination of either the positive or negative LED on the front panel for safety and convenience of the user.

Specifications

INPUTS

INPUT POWER - +24V ± 2%, regulated 0.1% @ < 250 mA

OUTPUTS

REGULATED HIGH VOLTAGE - 0 to ± 5000 VDC, continuously adjustable:

CURRENT LOADING - 0 to ± 2KV < 0.5 mA
± 2KV to ± 5KV < 0.1 mA

CONTROLS

ON-OFF - Front Panel 2-position toggle to enable or disable output

OUTPUT VOLTAGE - Front panel 5-turn direct readout dial permits continuous adjustment of the output voltage ± 0 to 5000 VDC

POLARITY - Internal shorting bar changes output polarity by reversing orientation

GATE - TTL logic input "0" or < 4K ohm resistor to ground required for HV OFF Open circuit resumes output

INDICATORS

OUTPUT VOLTAGE - edgewise output voltage monitor

POLARITY - front panel LED indicator lights for positive or negative polarity

PERFORMANCE

RIPPLE AND NOISE - < 2mV peak to peak at no load (< 1μA). 10 mV p-p at 0.5 mA.

OUTPUT STABILITY - long term drift of output voltage is < 0.01%/hr. and < 0.02%/8 hr. at constant input line voltage, load, and ambient temperature after a 30 minute warmup

REGULATION

LINE - < 0.001%
LOAD - < 0.002%
} Within rated operating range at a constant ambient temperature

METER - Front panel 0 to 5 kV meter. Accuracy ± 5% F.S.

OVERLOAD PROTECTION - power supply will withstand any overload, including a short circuit for an indefinite period, and will resume normal operation after manual reset.

ACCURACY - 0.25% of dial reading plus 10 volts (dial resolution)

OVERVOLTAGE - Comparator on output senses ≅ 10% overvoltage (tracking) and removes output drive. Latching circuit requires control switch OFF to ON to restore high voltage.

REAR PANEL CONNECTORS -

OUTPUT - SHV INHIBIT-BNC

INPUT - 3 pin MOLEX #03-06-1031 to mate with MOLEX #03-06-2032. Pin 1 to be ground and Pin 2 to be +24 volts.

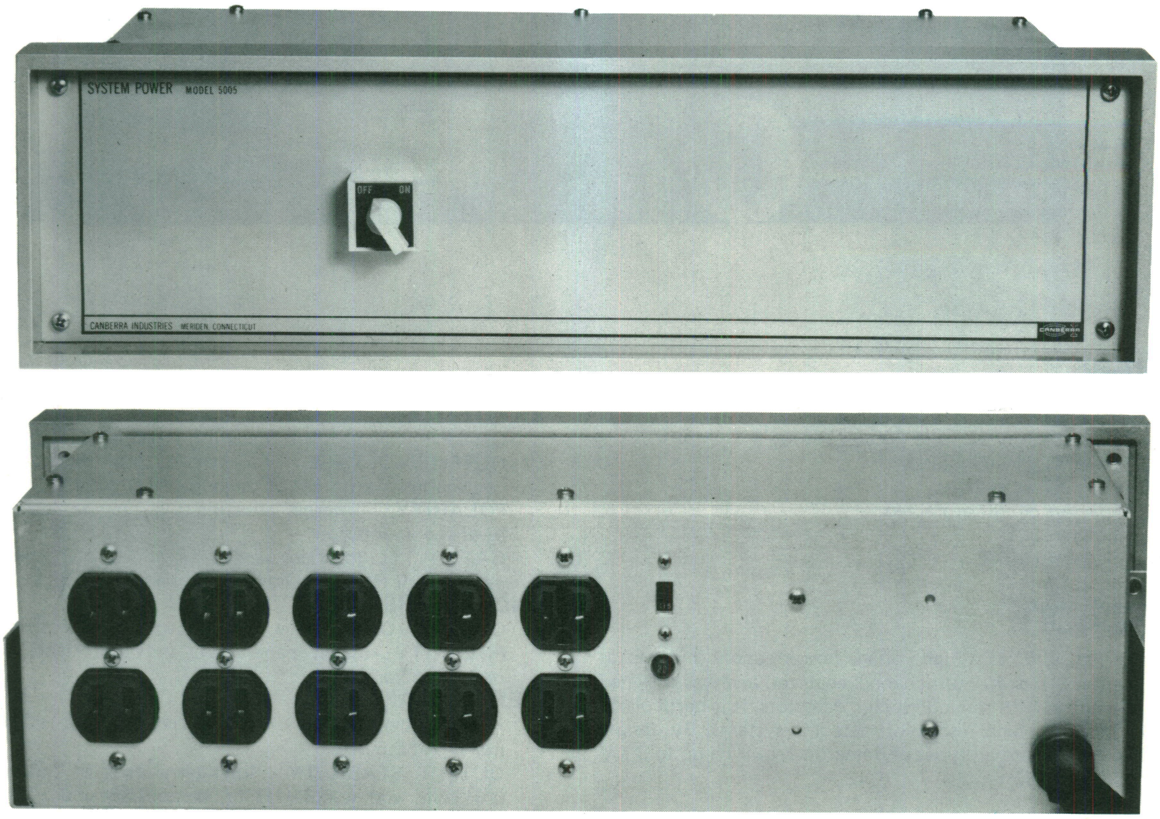
PHYSICAL

SIZE - 8.5 x 9.7 x 1.25 inches (20.8 x 23.8 x 3.1 cm)

NET WEIGHT - 3.8 lbs (1.7 Kgs)

SHIPPING WEIGHT - 6.0 lbs (2.7 Kgs)

Model 5005
System Power



Features

- Master power control
- 20 amp resetable circuit breaker
- Ten convenience outlets
- 220/110 volt ac, 50/60 Hz operation
- RFI filter

Description

The Model 5005 is designed for use with Canberra Nuclear Systems for protection, distribution and control of input ac power. The unit supplies RFI filtered ac power to eight standard power receptacles. Two additonal receptacles are supplied which are directly connected (unfiltered) to the ac input line for convenience.

Frequently, if a computer based system is not turned on or off in the proper sequence, memory loss or actual damage to system components can occur. The Model 5005 insures that all elements of the system are simultaneously turned on and off. As an added benefit, no additional connectors, drilling, or power wiring to a cabinet is required. The Model 5005 single rack mounts in a standard 19" cabinet.

Specifications

INPUTS

INPUT VOLTAGE - 100 to 130VAC, 50 to 60Hz, single phase or 200 to 260VAC, 50 to 60Hz, single phase

LINE CORD - Standard wall plug connector with twenty-three feet of #12 wire

OUTPUTS

Eight interference filtered and switched receptacles corresponding to input voltage and frequency

FRONT PANEL CONTROLS

ON/OFF - master switch to turn system on or off

REAR PANEL CONTROLS

110/220 VOLT SELECTION - slide switch to select proper input voltage; requires screwdriver to make selection

OVERLOAD PROTECTION - 20 amp resetable circuit breaker

PHYSICAL

SIZE - 19" wide (rack mount) x 5-1/4" high x 5-1/4" deep (48.26 x 13.34 x 13.34 cm)

All wiring is #12 wire

Five standard UL approved double-receptacle sockets

NET WEIGHT - 18 lbs. (8.10 kgs)

SHIPPING WEIGHT - 25 lbs. (11.25 kgs).

AP-1/AP-2
NIM Module Power Supply

Features

- Portable
- AP-1 accepts up to 4 single-width NIM
- AP-2 accepts up to 6 single-width NIM

Description

The Models AP-1/AP-2 NIM module power supplies provide mounting space and power sources for up to 4 NIM Modules (AP-1) and 6 NIM Modules (AP-2).

Specifications

INPUTS

INPUT VOLTAGE - 115 or 230VAC.

OUTPUTS

AP-1 - ±24V and ±12V at 350mA.
AP-2 - ±24V at 500mA and ±12V at 1A.

PERFORMANCE

REGULATION - AP-1 – 0.05%
AP-2 – 0.1%

RIPPLE - less than 3mV

CALIBRATION AND TEST INTRODUCTION

Introduction

When configuring a system, especially a timing or coincidence system, it is often necessary to test the component configuration for proper operation using a known input source. The instruments listed in this section can be used to accurately test and to properly configure individual components into a system to suit the application.

Also, these instruments may be helpful in investigating the malfunctions or linearity of the separate system components. The calibration and test equipment of this section can shape a pulse or pulse train to simulate the input conditions of ideal system use. In this manner, a verification or adjustment of the output can be made from the use of a known input which is free of detector limitations.

Features

The pulse signal sources (pulsers) described here vary according to the instrument each is capable of testing or calibrating, the functional tests each can perform, and the performance and accuracy each can achieve. Most Canberra preamplifiers have test inputs that can accept a pulser output. Pulser outputs may be fed directly into an amplifier, single channel analyzer, analog to digital converter or multichannel analyzer input. The pulsers may be used to perform stability or linearity checks on the equipment or system, to determine noise or pulse pair response, to align coincidence systems, to check overall system operations, or calibrate a pulse height analysis system. Although some pulsers are extremely versatile in functions, a tradeoff in performance and accuracy might exist. Limited purpose pulsers usually display more accuracy and performance because they are devoted to specialized tasks. This performance and accuracy consideration is important when calibrating high resolution systems, such as those used for Ge(Li), Si(Li) and Silicon Surface Barrier applications.

Systems having poorer resolution, or requiring system verification and time calibration, do not require as high a degree of accuracy or performance in the pulser used, but may require functional versatility. Features that are relevant to the performance and functions of a pulser are: output signals available, amplitude range, attenuation and normalization controls, repetition rate, pulse rise time/fall time constants, and stability and linearity specifications. Each of these features is important in determining which application the pulser is best suited for.
In the text that follows, applications will be provided that should help to illustrate the importance of each feature. A chart is included which outlines the important features of each pulser, and offers suggested applications.

Applications

The output signals that are available from the pulse generator are important in deciding which system it may be used to test. If the pulser simulates a preamplifier or detector output, it can be used with either a preamplifier or amplifier module as the input to the system you want to test. The 807 and 1407 pulsers are of this type.

The amplitude range of the pulser is critical to insure that the total range of the instrument tested is examined. This is especially true for linearity checks! If an instrument has a working range of .05 to 10V, it is important that the pulser's output is variable over the .05 to 10V range, also. The size of the smallest output voltage increment available and the degree of voltage output repeatability is more important to high resolution or precise linearity applications.

The attenuator controls facilitate instrument linearity checks by allowing a quick and accurate pulser output reduction to known fractions of the dialed amplitude. The 8210 pulser used primarily for channel profiles and stability checks of multichannel analyzers has a binary ladder attenuator which is extremely accurate and simple to use. Also, the normalization control of the 1407 allows for easy calibration of the attenuator dial so that outputs indicative of energy (keV, MeV) values can be dialed and read directly from the pulser attenuator control. This feature simplifies system calibration and set-up.

The stability and linearity specifications are the most important performance features of the pulser. In order for an instrument to be used to test other equipment, the performance specifications of the pulser should be better than the expected specifications of the instrument under test. If this is not true then the input source will not qualify as a known, and the test procedure is of no value.

Of the many Canberra pulse generators, the 1407 is the most versatile because of its rise and fall time constant selections. This feature makes the 1407 the best pulser to determine amplifier shaping time constant optimization and system signal conditioning limitations.

Canberra offers a wide assortment of pulse generators each differing in performance and assorted functions. Canberra is confident that one of the following instrument descriptions will satisfy your pulse generator requirements.

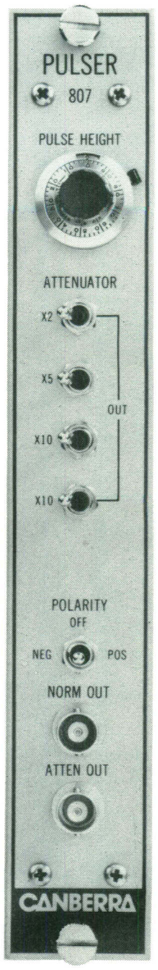
Pulser Comparison Chart

Pulser Model #	Output Simulated	Advise Use With	Applications	Amplitude Range	Type	Risetime	FallTime	Average Repetition Rate	Attenuators	Amplitude Stability	Integral Linearity	Amplitude Adjustments
807	Detector or Preamplifier	Preamplifier (Test Input) or Amplifier Input	• Determine Amplifier Noise and Linearity • Align Coincidence Systems • Calibrate Pulse Height Analyzers • Evaluate System Stability • Check Overall System Operation	±0 to ±10V	Normal	≤10nsec Fixed	70µsec Fixed	Either 50Hz or 60Hz Fixed	X2, X5, X10 And X10 or any product	.005%/°C <.05%/24 Hrs	<±.25%	10 turn Potentiometer
				±0 to ±10V (Normal x Attenuator)	Attenuated	(Same as Above)	(Same as Above)					
1407R	Constant Amplitude Variable Noise	Preamplifier (Test Input) or Amplifier Input	• Resolution and System Noise Checks • Gain Stability at Varying Pulse Rates • Baseline and Zero Shifts due to Count Rate • Pile-Up Effects	2.5mV to 250mV	Normal	100nsec	50µsec	10 turn pot Continuous Selection from 5Hz to 250KHz	X2, X5 or any product			10 turn Potentiometer
				+4V	Trigger (Logic Pulse)	100nsec	50µsec					
8210	Gaussian Shaped Amplifier Output	SCA Input or ADC Input or MCA Input	• Count Rate Shift Determinations • Channel Profile • Gain and Zero Shift • Count Rate Scatter • Linearity Spot Checking • General Trouble Shooting	±0V to ±10V (Hi Gain) or ±0 to 200mV (Lo Gain)	Normal	Selectable 1µsec, . 5µsec, 2µsec or 5µsec	50µsec Fixed	60Hz fixed	Binary ladder Attenuator, 1/2 to 1/8192 with 13 toggles	.005%/°C		Hi/Lo Gain Switch 10 turn, Coarse Control 10 turn, Fine Control
				+3.5V	Trigger (Logic Pulse)							

Model 807 Pulser

Features

- Simulates detector output signals
- Normal and attenuated outputs
- Output stability $<0.005\%/^{\circ}C$
- Linearity better than $\pm 0.25\%$
- Suitable for input to *any* Canberra preamp or amplifier



Description

The Canberra Model 807 Pulser generates a highly stable source of tail pulses which simulate the output of a detector/preamplifier combination (i.e., short rise time and long exponential decay time). By providing pulses of known amplitude, specific energy levels in a detector can be simulated. This single-width NIM module can therefore be used to set up and evaluate nuclear spectroscopy and counting systems before a live radiation source is used for actual experimentation.

Specifically, the Model 807 can be used to: (1) determine amplifier noise and linearity, (2) align delays in coincidence systems, (3) calibrate pulse height analyzers, (4) evaluate system stability, (5) check overall operation of a system before beginning experimental runs.

Separate Normal and Attenuated Outputs are provided for input to any Canberra Preamplifier or main amplifier. Output polarity may be either positive or negative via front panel control. The pulse shaping is exponential, exhibiting a rise time of less than 10 nanoseconds and a decay time constant of 70 microseconds. Pulse repetition rate may be either 50 or 60 Hz, dependent on the AC power line frequency.

Both outputs are simultaneously and continuously adjustable in amplitude by front panel ten-turn potentiometer control, over a range of 0 to ±10 volts (unterminated). Integral linearity of the Pulse Height control is better than ±0.25% of full scale. Accurate attenuation switches permit reducing the full scale pulse height from the Attenuated Output by factors of X2, X5, X10, X10, or any combination of these values. An internal zener-regulated power supply achieves the pulse generator's excellent output stability of less than 0.005% amplitude change per °C, and less than 0.05% over 24 hours.

Specifications

OUTPUTS

NORMAL OUTPUT - provides positive or negative (switch selectable) tail pulses; 50 or 60 Hz repetition rate (line frequency); pulse height 0 to 10V unterminated (0 to 5V into 100 ohms load); rise time $\leqslant$10 nsec exponential; fall time $\approx$70 μsec exponential decay time constant; Z_o = 100 ohms, DC coupled; front panel BNC connector

ATTENUATED OUTPUT - output specifications identical to Normal Output, except pulse height is divided by the attenuation factors selected; Z_o - 100 ohms, DC coupled; front panel BNC connector

CONTROLS

PULSE HEIGHT - front panel 10-turn lockable precision potentiometer simultaneously adjusts Normal and Attenuated Output pulse amplitudes, 0 to ±10V range (unterminated outputs), continuously adjustable

ATTENUATOR - four front panel toggle switches to select X2, X5, X10, X10 attenuation for Attenuated Output, 1000:1 dynamic range

POLARITY - front panel 3-position toggle switch to select POS or NEG output polarity, or to disable (OFF) mercury relay

PERFORMANCE

INTEGRAL NONLINEARITY - $<\pm 0.25\%$ of full scale

OUTPUT STABILITY - $<0.005\%/^{\circ}C$, $<0.005\%$ over 24 hours

RIPPLE AND NOISE - $<0.01\%$ RMS

OPERATING TEMPERATURE RANGE - 0 to +50°C, ambient

PULSE REPETITION RATE - 50 or 60 Hz, dependent on AC line frequency

CONNECTORS

NORMAL OUTPUT, ATTENUATED OUTPUT - front panel, BNC, UG-1094/U

POWER REQUIREMENTS

+24VDC — 15mA +12VDC — 0mA
- 24VDC — 15mA - 12VDC — 0mA
115VAC (50 or 60Hz) — 20mA

PHYSICAL

SIZE - standard single-width NIM module (1.35 x 8.71 inches) (3.43 x 22.13 cm) per TID-20893 (rev)

NET WEIGHT - 1.4 lbs. (0.6 kgs.).

SHIPPING WEIGHT - 6.4 lbs. (2.88 kgs.).

Model 1407
Reference Pulser

Features

- Stable line frequency and 90Hz tail pulse outputs
- Temperature stability <0.005%/°C
- Variable rise and fall time controls

Description

The Canberra Model 1407 Reference Pulser provides a source of stable tail pulses at line frequency or 90Hz to simulate the output from a detector/preamplifier combination. For system alignment or for checking system stability and linearity, the 1407 is essential.

The 1407 offers variable rise time, via front panel switch selection, from less than 10 to 250 nanoseconds, and variable fall time, via front panel switch selection, from 20 to 400 microseconds. Amplitude is continuously variable by a 10-turn PULSE HEIGHT potentiometer control from 0 to 10 volts with ±0.1% control nonlinearity. A second front panel 10-turn NORMALIZE potentiometer permits adjustment of the output to read directly in keV or MeV for the convenience of the user.

Front panel precision attenuators permit reduction of the ATTENuated OUTPUT by factors of X2, X5, X10, X10, X10, or any product of these values. By front panel switch selection, the pulser output frequency may be selected for LINE or 90Hz, to permit easy measurement of system resolution loss due to line frequency ripple.

Specifications

OUTPUTS

NORMAL OUTPUT - 0 to ±10 volts unterminated for triggering purposes; rise and fall times as selected by front panel controls; output impedance 93 ohms. If used with no termination the ATTENuated OUTPUT should either be terminated with 93 ohms or contain some attenuation factor.

ATTENuated OUTPUT - same as NORMAL OUTPUT, divided by attenuation factors selected; output impedance 93 ohms. If used with no attenuation factor and unterminated, the NORMAL OUTPUT should be terminated with 93 ohms.

PERFORMANCE

STABILITY - better than ±0.005%/°C; better than ±0.001%/10% line voltage change.

LINEARITY - better than ±0.1% integral.

FREQUENCY STABILITY - same as line frequency for 60Hz, better than 5% for 90Hz.

ATTENUATION ACCURACY - attenuator constructed of ±0.1% resistors.

ATTENUATION STABILITY - better than ±50ppm/°C.

CONTROLS

PULSE HEIGHT - ten-turn locking dial potentiometer to select pulse amplitude from 0 to 10 volts unterminated.

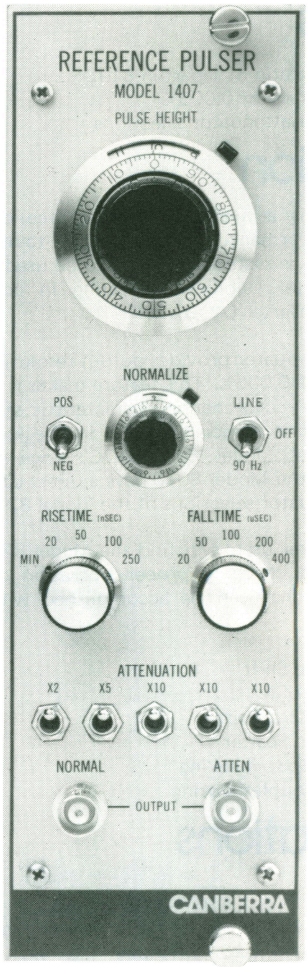
NORMALIZE - ten-turn locking dial potentiometer to permit normalizing PULSE HEIGHT potentiometer reading in keV or MeV; 2:1 adjustment range.

MODE - front panel toggle switch to select POS or NEG output polarity.

FREQUENCY - front panel toggle switch to select LINE or 90Hz repetition rate, or to disable mercury relay.

ATTENUATION - front panel toggle switches to select X2, X5, X10, X10, X10 attenuation for ATTENuated OUTPUT.

RISE TIME - front panel rotary switch to select MIN, 20, 50, 100, 250 nanosecond rise for ATTENuated OUTPUT into 93 ohms; NORMAL OUTPUT is always MIN.



FALL TIME - front panel rotary switch to select 20, 50, 100, 200, 400 microsecond fall time constant into 93 ohms; fall time control affects both outputs; for proper fall time constants, both outputs should be terminated with 93 ohms.

CONNECTORS

Both output connectors are front panel mounted BNC types.

POWER

+24V	—	25mA	+12V	—	20mA
-24V	—	25mA	-12V	—	20mA

PHYSICAL

SIZE - standard double width module (2.7 x 8.71 inches) (6.8 cm x 22.13 cm) per TID-20893 (rev.A).

NET WEIGHT - 2.8 lbs. (1.26 kgs).

SHIPPING WEIGHT - 5.0 lbs. (2.4 kgs).

Model 8210
Precision Pulser

Features

- Output resolution of 1 part in 8192
- Output accuracy of 0.005%
- Binary ladder attenuator selections

Description

The Model 8210 is a highly accurate source of signal pulses for calibration and performance testing of analog-to-digital converters and multichannel analyzer systems. It can also be used as a reference signal source for a digital stabilizer operating in conjunction with an analog-to-digital converter (ADC).

A binary ladder attenuator provides output resolution of 1 part in 8192 with an accuracy of 0.005%. This feature makes it possible to precisely track the amplitude versus channel characteristic of an ADC by additive switch selection. It is especially useful in checking operation of the Canberra Industries' Model 8070 ADC, since the binary address indicator lamps of the Model 8070 have a direct correspondence to the binary ladder attenuator selections of the Model 8210.

Multichannel analyzer users will find the Model 8210 an invaluable aid in maintaining and checking proper operation of their equipment. Performance tests that can be accomplished with the Model 8210 include:

- Count Rate Shift
- Channel Profile
- Gain and Zero Drift
- Count Rate Scatter
- Linearity Spot-checking
- General Troubleshooting

Specifications

OUTPUTS

TRIGGER OUT - amplitude, +3.5V @ 2mA

SIGNAL OUT - digital resolution, 1 part in 8192, integral linearity, ±0.005%; temperature coefficient, less than ±50ppm/°C; line voltage sensitivity, less than 0.005%, 105 to 125V; pulse output amplitude, high level 0-10V into 2K ohm load; low level 0-200 millivolts, 93 ohm load, direct output voltage, 0 to 17 volts into 25K ohms.

CONTROLS

AMPLITUDE - thirteen (13) toggle switches 1/2 to 1/8192 in a binary sequence: controls input to a binary ladder

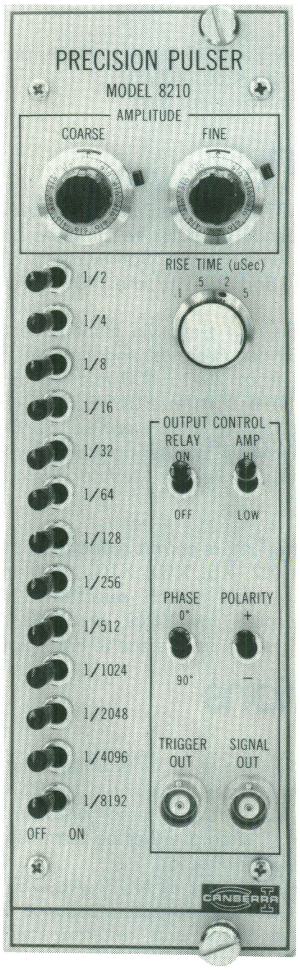
COARSE AMPLITUDE - ten-turn, wire-wound control attenuates output of binary ladder: resolution less than 0.02% of full scale

FINE AMPLITUDE - ten-turn, wire-wound control to adjust amplitude of reference power supply: resolution less than 0.0001% of full scale

RISE TIME - rotary switch to select rise time: settings are 0.1μsec, 0.5μsec, 2.0μsec, and 5.0μsec (pulse decay time, approximately 50μsec)

PHASE - toggle switch to adjust phase relative to the 60Hz line, positions are 0° or 90°

POLARITY - toggle switch to change polarity of output relative to ground



RELAY - toggle switch in ON position power applied to relay and pulses available on output connector: in OFF position relay de-energized and Precision DC voltage from COARSE control is available on the output connector

CONNECTORS

TRIGGER OUTPUT, SIGNAL OUTPUT - BNC

POWER - 42-pin Amphenol #202515-3

POWER

115VAC, 50/60Hz - 65mA

PHYSICAL

SIZE - AEC standard double-width NIM module (2.70 x 8.71 inches) (6.86 x 22.13 cm) per TID-20893 (rev.)

NET WEIGHT - 4.5 lbs. (2 kgs).

SHIPPING WEIGHT - 9.5 lbs. (4.28 kgs).

MULTICHANNEL ANALYZERS 4

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MCA INTRODUCTION

The multichannel analyzer is the heart of most experimental measurements since it performs the essential functions of collecting the data, providing a visual monitor, and producing output, either final results or raw data for later analysis. MCAs may be grouped into three basic categories:

	Canberra Model
1. Simple MCA – ● Portable ● Small Memory Size ● Some I/O Devices	Series 30
2. General Purpose MCA – ● Many Data Acquisition Modes ● Many Input/Output Devices ● Microprocessor-based functions	Series 40
3. Advanced MCA – ● Multiple ADCs ● Large Memory Size ● Microprocessor-based functions and Data Analysis	Series 80

A basic MCA is shown as a functional block diagram in Figure 1. Analog pulses (customarily 0 to 10 volt unipolar or positive-leading bipolar) are digitized by a Wilkinson type ADC, and then stored in memory. The channel number is the memory address, and is proportional to the input signal voltage. Each pulse is digitized and a count added to the appropriate memory location, so that a spectrum of number of pulses vs voltage is obtained.

The range of channels available with an MCA is a minimum of 1024 to a maximum of 16,384. ADC resolutions are available from 2048 to 8192 channels. In general, the higher resolution detectors require more channels and better ADC resolution in order to have sufficient number of channels in the peak. Also, a greater energy range requires a greater number of channels. A general guide to detector and memory size is given in Table I for several detectors. It is common to purchase a larger memory than required so that a typical spectrum is acquired in one half of memory and a reference spectrum can be stored in the other half for comparison.

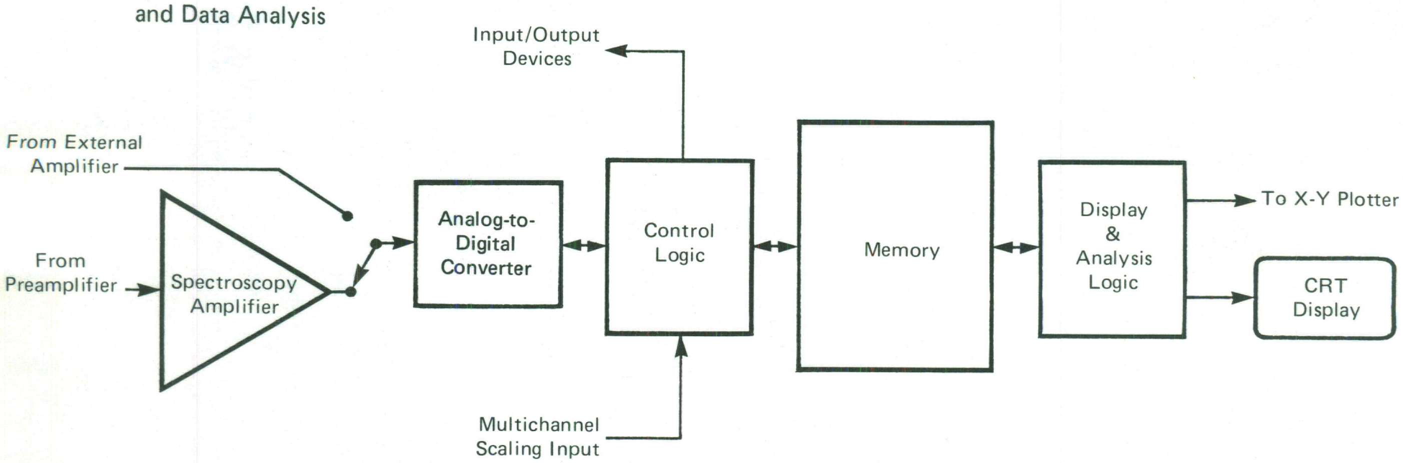


Figure 1. Multichannel Analyzer Functional Block Diagram.

DETECTOR	TYPICAL RESOLUTION	TYPICAL ENERGY RANGE	MEMORY SIZE (Channels)
NaI	8% (52keV) at 662keV	1 or 2MeV	512 or 1024
Silicon Surface Barrier	30keV	4 or 8MeV	512 or 1024
Si(Li)	180eV	30 or 50keV	512 or 1024
Ge(Li)	2keV	2MeV or 4MeV	2048 or 8192

Table I. Detector and MCA Memory Size.

ANALOG-TO-DIGITAL CONVERTER CHARACTERISTICS

The basic digitizing of an input analog signal is performed by the analog-to-digital converter (ADC). The Wilkinson and successive approximation processes are used in ADCs, but the Wilkinson ADC is superior for spectroscopy because of its good linearity compared to successive approximation. However, the successive approximation ADCs are much faster, and hybrid ADCs (part successive approximation, part Wilkinson) have been developed to combine fast conversion with good linearity.

The Wilkinson ADC digitizes a pulse by charging a capacitor to the amplitude of the input, and then discharging the capacitor at a constant rate. During the discharge time a crystal controlled pulse train is counted in a register. When the ramp has returned to the baseline, the number in the register represents the input signal pulse height. This process is indicated schematically in Figure 2.

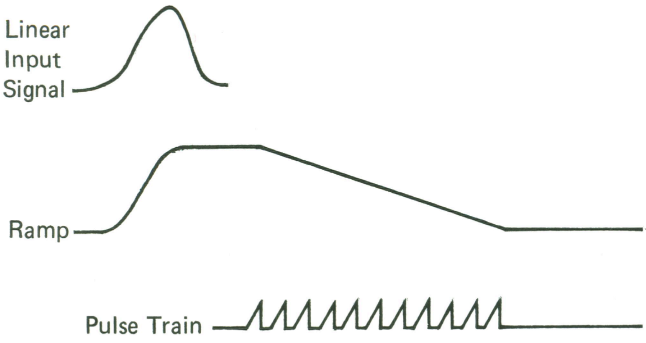


Figure 2. ADC Ramp and Pulse Train.

Specific ADC characteristics relating the ramp slope, number of channels, linearity, plus other features, are listed here and described below:

- ADC Resolution
- Conversion Gain
- Dead Time and Live Time
- Digital Offset
- Linearity
- Coincidence and Anticoincidence Gating
- Discriminators and ADC Zero Level
- Digital Stabilization

The resolution of the ADC in channels is related to the slope of the ramp and the crystal controlled clock frequency. (The resolution is actually 1 divided by the number of channels, but is commonly referred to as the number of channels.) The "conversion gain" specified in channels per input voltage range, or just channels, refers to the slope of the ramp as well. ADCs for spectroscopy are available with resolutions of 2048, 4096, or 8192 channels (11, 12, or 13 bits), and clock frequencies of 50 to 100MHz.

The higher clock frequency allows a shorter ramp time for the same number of channels, or a lower dead time. Dead time refers to the time the ADC is busy (or "dead") while processing one pulse and cannot accept another. The conversion time for a Canberra 50MHz ADC is given by . . .

$$T = 2.5 + 0.02\ (N+X) \text{ microseconds}$$

where N = converted channel number
X = amount of digital offset.

The 2.5 microseconds fixed time follows the pulse peak and precedes the ramp generation (see Figure 2). The total dead time is slightly longer since it includes the input pulse width and the transfer time of ADC output to MCA memory. These are referred to in Canberra specifications as linear gate time and memory cycle time.

Dead times are many microseconds. For example, for $N = 1000$ and $X = 0$, the conversion time is 22.5 microseconds. To lower the dead time and allow higher counting rates, a 100MHz ADC can be selected ($T = 2.5 + 0.01\ (N+X)$).

The count rate capability may be further improved by use of the Canberra 8080 Fast ADC, which is part successive approximation for speed and part Wilkinson for good linearity. This unit has an average conversion time of 9.5 microseconds (ranging from 6 to 13 microseconds), and can be operated with a fixed conversion time of 13 microseconds or longer. It should also be noted that high count rate capability depends strongly upon the linear electronics used as well. Consult the Application and Technical Reference and Spectroscopy Amplifiers sections of this catalog.

The percent dead time is usually indicated on the CRT or a front panel meter. Compensation for dead time is provided in MCAs by acquiring data for "live time" periods, rather than clock or true time. The live time is obtained by gating off a clock with the dead time. The Series 30 operates in live time mode only, while the 8100 and Series 80 can be preset for live or true time. Time is stored in channel 0 of the Series 30 and 8100 spectra, while the Series 80 stores live time in channel 0 and true time in channel 1.

Digital offset mentioned above is the capability of subtracting a specified channel number from the converted channel number before memory is accessed. This is equivalent to using a biased amplifier, but has the advantage of being digital. Digital offset is used frequently in alpha spectroscopy to remove the lower energy ranges and expand a higher energy range across the full memory. Digital offset is also used to collect data at twice the range of an MCA memory. For example, with a 2048 channel ADC gain and a 1024 channel MCA, digital offset is required to collect the top half of the spectrum. A digital offset of 1024 allows ADC channels 1024 to 2047 to be stored in the 1024 channels of data memory.

Linearity of an ADC is given in terms of integral and differential nonlinearity. Integral nonlinearity may be described as the deviations from a linear relationship of pulse height vs channel number, while differential nonlinearity may be described as the variation in channel width from one channel to another. Typical values are less than 0.025% (about 1 channel in 4000) for integral nonlinearity and less than 1% for differential nonlinearity.

Modern MCA's usually have an energy calibration function which provides a linear calibration scale for the energy axis, the accuracy of which is dependent on the linearity of the ADC and associated detector system.

In nuclear systems with high-resolution detectors, errors resulting from non-linearities become more apparent and a straight-line calibration may not be adequate. In this case a more complex algorithm will be used, and sophisticated MCA's such as the Series 80 can be calibrated using an expression of the form

$$A \times \text{Ch.\#}^2 + B \times \text{Ch.\#} \pm C$$

This formula more accurately describes the type of non-linearity encountered and therefore allows a better fit of the actual energy scale to the display scale.

ADCs are also provided with coincidence or anti-coincidence gate capability (or no gate requirements). On a simple MCA like the Series 30, the gate signal must completely overlap the input signal (by 0.5 microseconds before and after the input pulse passes through the lower level discriminator setting). On the 8100 and Series 80 MCAs, the coincidence gating requires only a pulse, rather than a long signal. This pulse need only be 100 nanoseconds wide and ±2.5 to 7 volts high. A standard SCA output pulse is adequate. There is also provision (Late Coincidence Mode) for allowing the gate pulse to occur after the start of the input pulse, as long as it occurs within the linear gate time (from lower level discriminator crossing through peak maximum to 90% of peak height — see Figure 3).

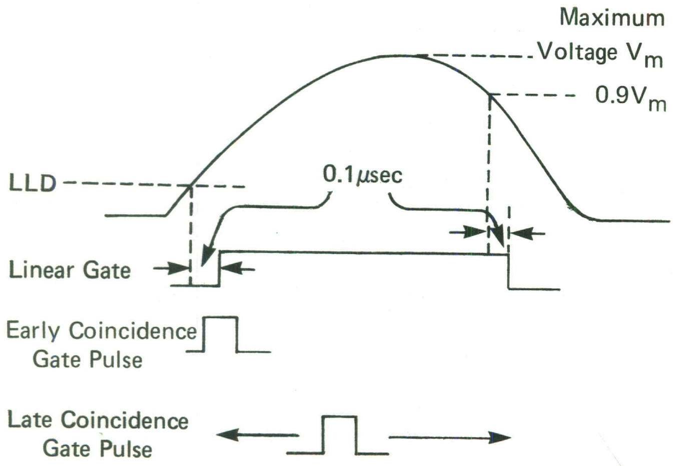


Figure 3. Input Pulse and Coincidence Gate Timing.

DC level or slowly varying signals may be sampled and digitized to obtain an amplitude distribution curve. When The ADC is set for sampling mode (by internal jumper on the Series 80 ADC), a sampling signal of 0.5 to 30 microseconds at the gate input determines the pulse width to be digitized.

Lower and upper level discriminators allow rejection of pulses from the conversion process if outside the window range selected. The independent SCA output based on these discriminators is useful as an input to multichannel scaling. A pulse height spectrum is collected, and the lower and upper level discriminators are set to bracket the peak of interest.

The ADC zero level, or analog baseline, is adjustable over a small range in order to allow precise setting of channel 0 to zero volts. The ADC zero setting is slightly dependent upon input pulse shape and conversion gain.

ADC stability is typically ±0.01% per °C for zero or gain, and long experiments may require an external stabilization. A digital stabilizer, the Canberra Model 8200, provides zero or gain stabilization (or both with 2 8200 units) in the Canberra 8040, 8070, 8070A, and 8080 ADCs. A peak in the spectrum is maintained at the same position by changing the ADC gain or zero, thus correcting for drift anywhere in the detector, preamplifier, amplifier, and ADC system.

Canberra ADC specifications are summarized in a chart in Table II of this introduction.

CRT DISPLAY

The CRT Display is an integral part of a MCA, providing a graphic representation of the accumulated data, the axes normally indicating energy versus intensity on linear scales. The horizontal scale is adjustable over a range of memory channels, and the vertical scale, representing the data content of the channels, is provided with a selection of ranges. On some MCA's such as the Series 80 there is an automatic range-changing facility which provides the benefit of routine output to a X-Y polotter on an optimum scale without the need for operator intervention. Logarithmic scales are useful for comparison of data which would otherwise be on different linear scales, and the square root display of the Series 80 is useful since the statistical uncertainty of the data in a channel is proportional to the square root of the data, and the vertical displacement on the display for the error is the same for any count level in any channel.

Horizontal scale expansion is provided so that the spectrum may be examined in detail, and spectra may be overlapped for comparison.

Groups of adjacent channels may be defined as a Region of Interest, and these channels are intensified on the display for identification. Whether the regions are delineated manually or automatically, the limits of regions may be used for data processing. For example, the intensified region can represent the boundary of a peak and the average of the end-points are then used in the calculation of the peak area.

MCA's using internal microprocessors are capable of displaying alpha-numeric characters in combination with the graphics, so that qualitative and semi-quantitative results can be printed on the display and, in some case, copied onto an X-Y recorder. These preliminary results are derived from information indicated either by regions of interest or moveable cursors. Cursors, of course, are useful in setting up regions of interest and specifying points of scale expansion, as well as indicating found data such as peak location.

The alpha-numeric characters are used interactively with the front-panel operator on sophisticated MCA's for parameter definition such as preset accumulation times, calibration curves and so on. LEARN tasks, and equations specified in DEFINE/USE options of the Series 40, are set up using the display characters facility in the same manner.

The information displayed is always, in Canberra MCA's, under the control of dedicated electronic circuitry so that the display and acquisition data are independent of each other. Actual counting rate is unaffected by display manipulation.

Table II. Analog-to-Digital Converter Specifications

Feature	Internal ADC's			External ADC's			
	Series 30	**Series 40**	**Series 80**	**8070**	**8070A**	**8075**	**8080**
Mounting				Rack Mount	Rack Mount	Rack Mount	Rack Mount
Clock Frequency (MHz)	50	100	100	50	100	100	>100 *
ADC Resolution (channels)	2048	8192	8192	8192	8192	8192	8192
Input Signal							
Voltage Range (Positive)	0 - 8	0 - 10	0 - 10	0 - 12	0 - 10	0 - 10	0 - 10
Rise Time (μs)	0.1 - 5	0.25 - 30	0.25 - 30	0.25 - 30	0.25 - 30	0.25 - 30	0.25 - 30
Minimum duration (μs)	1	1	1	0.5	1	0.5	1
Conversion Gain (channels)	512 - 2048	256 - 8192	256 - 8192	256 - 8192	256 - 8192	256 - 8192	256 - 8192
Discriminators							
LLD	0 - 125%	0 - 110%	0 - 110%	0 - 100%	0 - 110%	0 - 110%	0 - 110%
ULD	0 - 125%	0 - 110%	0 - 110%	0 - 100%	0 - 110%	0 - 110%	0 - 110%
Zero	0 - ± 20%	0 - ± 6%	0 - ± 6%	0 - 6%	0 - ± 6%	0 - ± 6%	0 - ± 6%
SCA out	No	Yes	Yes	Yes	Yes	Yes	Yes
Digital Offset (channels)							
Range	0 - 1792	0 - 8160	0 - 8192	0 - 8160	0 - 8160	0 - 8160	0 - 8160
Step size	256	32	1	32	32	32	32
Maximum Non-Linearity							
Integral	± .075%	± .025%	± .025%	± .025%	± .025%	± .025%	± .025%
Differential	± .9%	± .1%	± 1%	± .5%	± .75%	± .75%	± 1%
Coincidence Gate							
Coin	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Anti-coin	No	Yes	Yes	Yes	Yes	Yes	Yes
Sampling mode	No	Yes	Yes	Yes	Yes	Yes	Yes

* Worst Case Conversion Time of 13μsec, any channel.

DATA ACQUISITION MODES

There are many variations on simple pulse height analysis with an ADC, display and memory that are available on most MCAs. These are summarized here:

- Pulse Height Analysis (PHA)
- Internal Preamplifier, Amplifier and Pileup Rejection
- Multi-input PHA
  - Mixer/Router and Single ADC
  - Multiplexer and Multiple ADCs
- Dual Parameter
- List Mode
- External ADC
- Digitally Stabilized ADC

- Multichannel Scaling (MCS)
- Multi-input MCS

Multichannel scaling uses each memory location as a scaler to store counts, bypassing the ADC (see Figure 1). The channel location can be automatically advanced by an internal clock, or by external pulses. Multichannel scaling is convenient for half-life measurements, Mossbauer experiments, and data collection in which an array of scalers is needed to collect sequential output, such as from a spectrometer scan.

Data acquisition is made more complete by inclusion of an amplifier within the MCA, or a preamplifier/amplifier combination as in the Series 30. The Series 30 has an optional high voltage supply that can be plugged in so that a complete NaI detector to MCA system consists of the detector and tube base and all else within the MCA.

The front end modules used for signal processing on the Series 80 MCA provide a 100MHz ADC and sophisticated data acquisition capabilities. The 8622 PHA/MCS has a general purpose spectroscopy amplifier and 20MHz MCS counting, with only 250 nanosecond dead time between channels. The Model 8623 PHA/LTC includes a Ge(Li) spectroscopy amplifier and a pulse pileup rejection circuit. At high count rates pulses will randomly be too close in time in the detector to be resolved and will result in spurious data. By examining the leading and trailing edges of each pulse the 8623 unit rejects pileup pulses, and then performs the necessary additional correction to the dead time. The Model 8624 is an ADC with mixer/router, each of the 4 inputs having a separate linear gate and the capability of independent start and stop times. Further details are given in the specification sheets.

Pileup rejection can make important corrections to the data, resulting in a much higher accuracy in determining peak intensities. The following example shows how much of an effect can occur.

Consider the experimental set-up shown in Figure 4, which is a typical Ge(Li) plus MCA system used to count a Zn-65 source. The geometry and strength of the source were such that the detector produced 1K counts per second, which yields a peak net area in the MCA of 53,273 counts after a 500 second count, assuming the Zn-65 source, the geometry, and the count time all remain constant for all analyses (counting statistics aside). The 53,273 count peak net area value can then be considered as a reference value for determining the affect of count rate on the accuracy of the data.

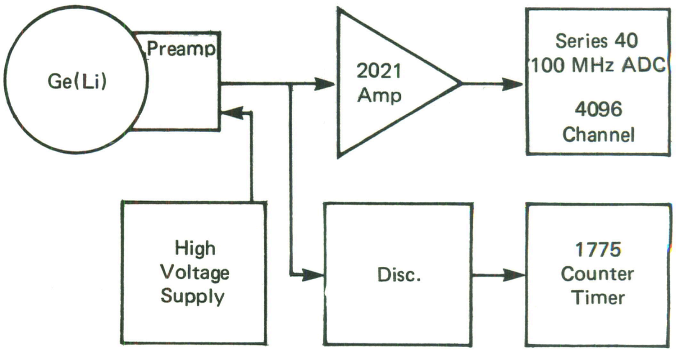


Figure 4. Ge(Li) System.

The total count rate of the system was then increased by adding increasing amount of Cs-137 to the counting geometry. After each count rate increase, a 500 second count was taken and the Zn-65 peak net area measured. This was then compared to the initial reference value and the percent deviation ("count rate error") computed. The results of this experiment are shown in Table III.

Count Rate	Approx. Dead Time	Zn^{65} Net Area	Error
1K	1%	53,273	0.00%
5K	12%	51,411	– 3.49%
10K	25%	48,843	– 8.32%
15K	35%	46,428	–12.85%
20K	45%	43,428	–18.48%
25K	52%	41,687	–21.75%
30K	59%	40,145	–24.64%
35K	62%	37,369	–29.85%
40K	66%	35,715	–32.96%

**Table III.
Effect of Count Rate on Data Accuracy.**

At 40K cps, the net area of the Zn-65 peak is in error by 33%! Even at 10K cps there was a discrepancy of over 8%. And, this is all due to the fact that the system did not have any means of compensating for pulse pileup in the spectroscopy amplifier.

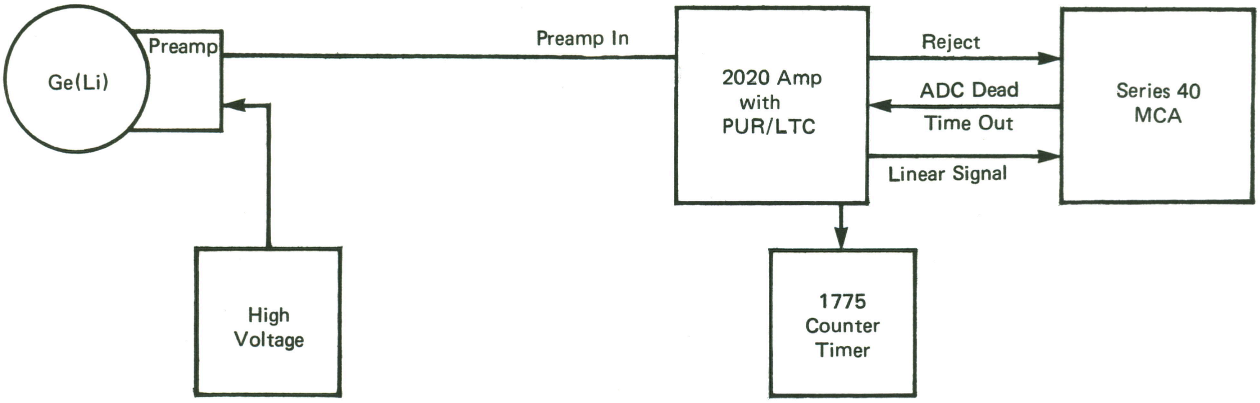


Figure 5. Ge(Li) System with PUR/LTC.

The system was then reconfigured as in Figure 5 to include a pulse pileup rejector/live time corrector (PUR/LTC) circuit and the experiment was run again. The resultant data is shown in Table IV. The presence of the PUR/LTC has reduced the error at 40K cps from 33% to 4.6%; now an accurate quantitative analysis is possible.

Count Rate	Approx. Dead Time	Zn^{65} Net Area	Error
1K	8%	52,485	+0.00%
5K	25%	52,614	+0.246%
10K	43%	52,345	-0.267%
15K	57%	52,052	-0.825%
20K	67%	51,821	-1.265%
25K	75%	51,360	-2.143%
30K	80%	50,313	-4.138%
35K	85%	50,578	-3.633%
40K	89%	50,076	-4.590%

Table IV.
Effect of PUR/LTC.

From the above experiment it becomes apparent that a PUR/LTC capability is a must for high count rate situations, and should be a major factor in selecting an MCA for those applications where high count rates are anticipated. The PUR/LTC is internal to the Series 80 MCA, as shown in Figure 6.

Multiple inputs from several detectors in PHA can be handled with a mixer/router in which each detector input goes to the same ADC, but for which a different section of memory is selected by routing bits. For low to moderate count rates a mixer/router provides an inexpensive way to collect data from several detectors.

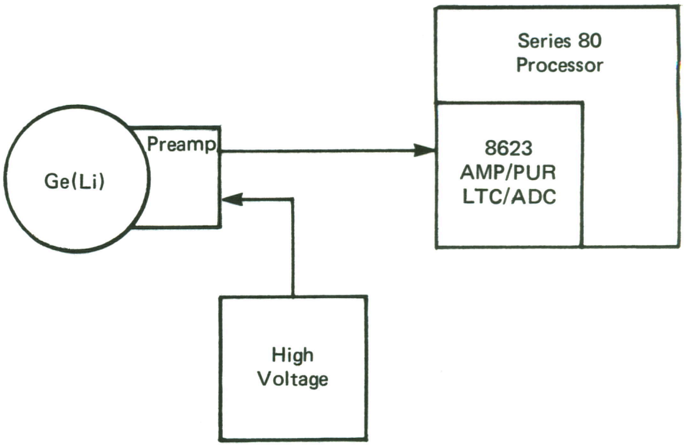


Figure 6. Ge(Li) and Series 80 PHA/LTC.

For high count rates, or when each detector must have a different ADC conversion gain or range, one can use an ADC multiplexer, such as the Model 8220A with the Series 40 or multiple front end modules (8621, 8622, 8623, or 8624) and an 8683A Expansion Chassis with the Series 80 MCA. Independent start and stop times for each ADC are provided by the processor in the Series 80, and by 8241 Time Bases with the 8100 MCA.

Multiple MCS inputs are available with the 8220A for the Series 30, and Series 40, and by using several 8622 PHA/MCS units and an 8683A Expansion Chassis with the Series 80 MCA.

DUAL PARAMETER

Using the Model 8634 Multiparameter Unit for acquisition control, the Series 88/MP provides simultaneous Dual Parameter, multi-input PHA, and multi-ADC List Mode data collection. All needed address routing and gating logic is contained within the 8634, and all data storage is via Direct Memory Access, insuring maximum throughput.

Overall system control, data display, and I/O is performed via the Series 88/MP processor. An enhanced display controller, special multiparameter firmware, and a new operator's console yield a convenient man:experiment interface.

Internal firmware functions provide basic data analysis at the touch of a button. An optional computer interface and available FORTRAN-callable subroutines allow on-line operation from both RT-11 and RSX-11M based PDP-11 family Host Computers. From basic data collection through on-line interactive operation, the Series 88 Multiparameter System provides a cost-effective solution to your multiparameter needs.

Table VI contains a selection guide to MCA Accessories for Canberra MCA's.

ADVANCED MCA FUNCTIONS

The Series 80 is a multiple microprocessor-based multichannel analyzer, capable of simultaneous data acquisition, display, analysis and input/output for one to four ADCs. This is accomplished by distributed processing, as shown in Figure 7.

The use of microprocessors allows extensive and sophisticated data analysis to be performed within the MCA, so that final results can be displayed and printed out, rather than just the raw spectrum. These analysis options (Models 8641, 8642, 8643, 8644, and 8645) are described in detail in the Analysis Options specification sheet. A summary of these capabilities is as follows:

- Energy Calibration (First or Second Order)
- Peak Search
- Peak Net Area
- Ratio Calculation
- Spectrum Normalization
- Spectrum Stripping
- Spectrum Smoothing
- Isotope Identification
- Quantitative Isotopic Analysis
- Automatic Program Sequence (Learn/Execute)

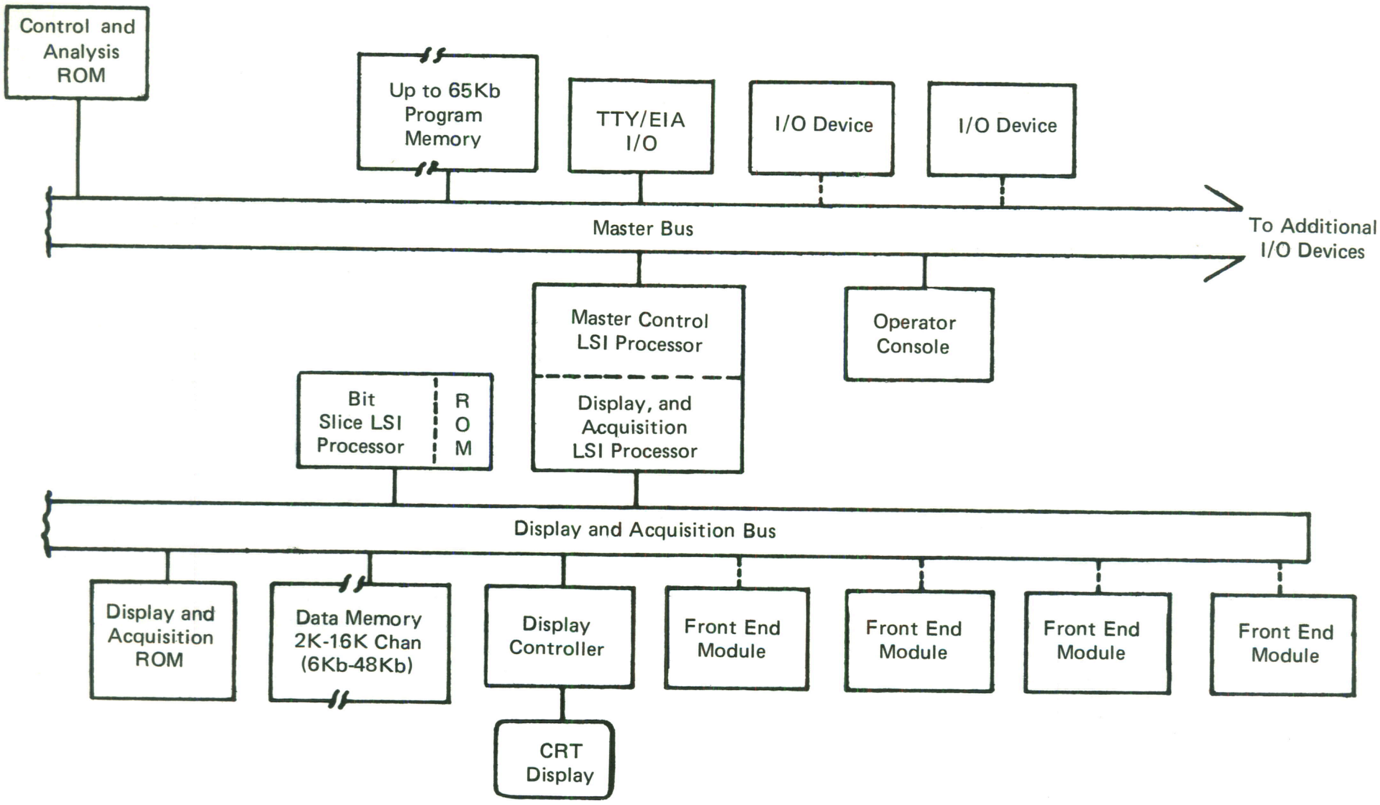

Control and Analysis ROM
Up to 65Kb Program Memory
TTY/EIA I/O
I/O Device
I/O Device
Master Bus
To Additional I/O Devices
Master Control LSI Processor
Display, and Acquisition LSI Processor
Operator Console
Bit Slice LSI Processor
ROM
Display and Acquisition Bus
Display and Acquisition ROM
Data Memory 2K-16K Chan (6Kb-48Kb)
Display Controller
Front End Module
Front End Module
Front End Module
Front End Module
CRT Display

Figure 7. Series 80 Architecture.

Energy Calibration
A least squares fit to two or more pairs of energy and channel number points calibrates the ADC range in energy (eV, keV or MeV). Second-order calibration is also provided to allow more precise calibration over the entire range. Calibration in units of time (microseconds, milliseconds, or seconds) is included for multichannel scaling.

Peak Search
Calculating the location of peak centroid positions allows automatic analysis of unknown spectra commonly used with Ge(Li) detectors.

Peak Net Area
The counts in the peak are calculated by subtracting a straight line background drawn between the end points of the region of interest set about the peak (by the peak search routine or manually). End point averaging over a user-selected number of channels is provided to reduce the error when background determination is very uncertain. The error in the net area, including uncertainty in background, is also calculated. Calculation details are given in the Applications and Technical Reference section.

Ratio Calculation
The ratio of counts in two channels, integral of counts in two regions of interest, or of two peak net areas can be calculated.

Spectrum Normalization
The counts in every channel of a spectrum may be multiplied by a factor for comparison with other spectra.

Spectrum Stripping
A background or reference spectrum can be subtracted from another spectrum. The background spectrum may be normalized so that the calculation of Final Spectrum = Initial Spectrum - Rx (Reference Spectrum). R is the last value of the ratio calculated (as above), or can be set by the user. R may be negative to allow addition of spectra.

Spectrum Smoothing
Both three-point and five-point smoothing are provided for full or partial spectra.

Isotope Identification
An internal isotope library is scanned to find any entries that are within an energy window (user selectable) of the peak in the spectrum. A user programmable library region is provided for isotopes not in the standard library, or for X-ray and/or alpha peaks.

Quantitative Isotopic Analysis
If the peak net area and isotope identification are determined, it is only necessary to know 1) the half life 2) the number of gamma rays per disintegration, and 3) the detector efficiency to calculate the activity of the isotope in the sample in microCuries. This capability provides complete analysis of unknown samples within the MCA.

Automatic Program Sequence (Learn/Execute)
Any sequence of selected front panel button operations can be stored in a list and recalled for execution on command. This list of up to 32 steps can include ADC setup, preset values, input/output, and analysis. There are 7 such 32 step sequences resident at one time, and can be connected together for longer individual sequences.

INPUT/OUTPUT DEVICES

Input/Output devices range from terminals to magnetic tape to computer interfaces. Descriptions of these devices are found with the MCA accessories section.

- Terminals - Teletype, Texas Instrument, or DECwriter
- Line Printer
- Cassette Tape
- Magnetic Tape
- Dual Floppy Disk
- X-Y Plotter
- Serial Computer Interface

SELECTION CHARTS

The following MCA Selection Chart describes the various Canberra MCAs in terms of the items discussed in the previous sections. Details on the specifics of each MCA, its options, etc. can be found in the specification sheets for the individual units. An ADC Specification Chart and an MCA Accessories Application Guide are also included. Your local Canberra representative will be pleased to work out the details on configuration and price as required for your application.

Table V. Multichannel Analyzer Selection Chart.

Feature	Series 30	Series 40	Series 80
Spectroscopy Amplifier			
NaI(Tl)	Yes	Yes	Yes
Utility Ge(Li)		Yes	Yes
High Count Rate Ge(Li)			Yes
ADC Resolution			
2048 Channels	Yes	Yes	Yes
4096 Channels		Yes	Yes
8192 Channels		Yes	Yes
External Data Acquisition			
Mixer/Router	Yes	Yes	Yes
Multiple ADCs		Yes	Yes
Multi-input MCS	Yes	Yes	Yes
Dual Parameter			
Data Memory			
1024 Channels	Yes	Yes	
2048 Channels			Yes
4096 Channels		Yes	Yes
8192 Channels		Yes	Yes
16,384 Channels			Yes
Analysis Function			
Region of Interest	Yes	Yes	Yes
Integral	Yes	Yes	Yes
Compare	Yes	Yes	Yes
Multiple ROI's	Yes	Yes	Yes
Energy Calibration		Yes	Yes
Net Area		Yes	Yes
Fractional Strip		Yes	Yes
Isotope Identification			Yes
Quantitative Analysis			Yes
Input/Output			
Hard Copy Terminal	Yes	Yes	Yes
EIA RS232C	Yes	Yes	Yes
Printer	Yes	Yes	Yes
X-Y Plotter	Yes	Yes	Yes
Cassette Tape	Yes	Yes	Yes
Magnetic Tape		Yes	Yes
Computer Interface & Software		Yes*	Yes*
Disk Mass Storage			Yes

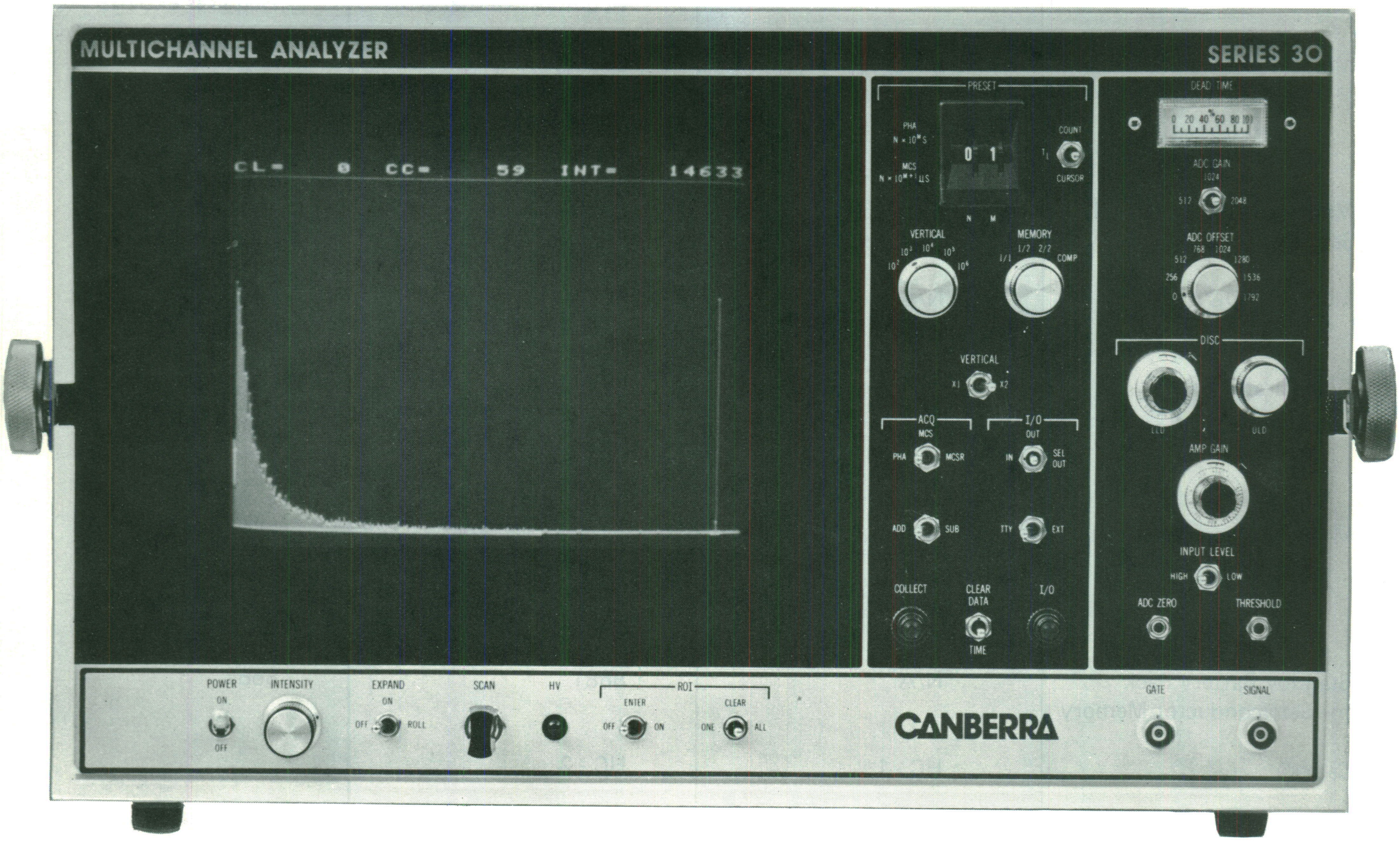
Note: Yes indicates feature is available. Check specific instrument literature for cost, standard feature vs. option, etc.

*Either the Series 40 or the Series 80 is available interfaced to a computer. These are known as JUPITER systems and are described in the section on Systems.

Table VI. Application Guide for MCA Accessories.

Item	Series 30	Series 40	Series 80
Tag Word Generator	N/A	Standard Feature	Standard feature
External ADC Interface (for 8060, 8070, 8070A or 8080 ADC)	N/A	Requires 4223	8633
Digital Stabilizer	N/A	4233 Requires external ADC	8200 Requires external ADC
Mixer Router	8220A Requires 3100 - 06	8220A Requires 4231 (8220 for external ADC)	8624 (8220 for external ADC)
Multi-input Multichannel Scaling	8220A Requires 3100 - 06	8220A Requires 4231	Multiple 8622's Requires 8683A
Multiple ADC's	N/A	8420 Requires 4223	8683A and any ADC's
Dual Parameter	N/A	N/A	N/A
Magnetic Tape Controller	N/A	7 track: 8531A 9 track: 8531A/9 Requires: I/F	8661
Standby Battery Pack for Semiconductor Memory	N/A	8681	8681
Camera	HC - 1	HC - 2	
Carrying Case	CC31	Consult Factory	Consult Factory
Battery Inverter	RPS - 310	RPS — 310	N/A

Series 30 Multichannel Analyzer


MULTICHANNEL ANALYZER
SERIES 30
CL= 0 CC= 59 INT= 14633
PRESET
COUNT
CURSOR
VERTICAL
MEMORY
COMP
DEAD TIME
ADC GAIN
ADC OFFSET
DISC
AMP GAIN
INPUT LEVEL
HIGH
LOW
ADC ZERO
THRESHOLD
ACQ
PHA
MCS
MCSR
I/O
IN
OUT
ADD
SUB
TTY
EXT
COLLECT
CLEAR DATA
TIME
POWER
ON
OFF
INTENSITY
EXPAND
ROLL
SCAN
HV
ROI
ENTER
CLEAR
ONE
ALL
CANBERRA
GATE
SIGNAL

Features

- **9" Diagonal CRT Display**
- **1024 Channels, 10^6-1 counts per channel memory**
- **50MHz, 2048 Channel ADC**
- **Built-in Preamp/Amp**
- **Plug-in Option for HVPS or Ge(Li) Amp**
- **Multiple Regions of Interest**
- **Digital Integrator and Alphanumeric Character Generator**
- **Built-in Teletype, EIA, and Cassette I/O**
- **Lightweight and Low Power**

Description

The Canberra Series 30 Multichannel Analyzer is a full-feature 1024 channel MCA in a compact, lightweight, and low power consumption package. The Series 30 provides the performance needed for the laboratory, the large screen CRT needed for the classroom, and the physical characteristics needed for the field.

Standard features include a Preamp/Amp, 2K 50MHz ADC, 1024 channels, 9" CRT, Digital Integrate, and TTY/EIA/Cassette I/O interfacing. Low cost plug-in options provide a Detector HVPS or Ge(Li) Amp, Parallel Printer Output, and X-Y Plotter Output. Wiring Options are available for Mixer/Router Operation, Sample Changer Control, and External MCS Control.

A full alphanumeric character generator and built-in digital integrator greatly enhance the utility of the large screen CRT display. Multiple Regions of Interest, Digital Display Expansion, and Spectrum Overlap greatly facilitate visual data analysis.

Canberra Series 30. The Full-Feature small MCA.

Specifications

SIGNAL PROCESSING

PREAMPLIFIER/AMPLIFIER

TYPE - Charge sensitive for use with the negative current pulses from a photomultiplier tube anode

SHAPING - RC passive differentiator and single pole active integrator using 1µs unipolar shaping with a DC restorer

GAIN - 240mV/picocoulomb maximum with a 20-1 range using a 10-turn helipot

STABILITY - Less than .01%/°C of full scale

NONLINEARITY - Less than .05% of full scale

OVERLOAD RECOVERY - Will recover to 2% of full scale output in 2.5 nonoverloaded pulse widths for a X100 overload

PEAK SHIFT - For CO^{60} 1.33MeV, peak shift will be less than 0.75% from 2KHz to 50KHz

ANALOG DISCRIMINATORS

ULD - Single turn control used to select the upper limit of the ADC input from 0 to 125% of input range

LLD - 10-turn locking control used to select the lower limit of the ADC input. Control range from 0-125% of input range

THRESHOLD - Used to set the minimum input level to which a pulse must decay before another conversion can take place. Range from 0-5% of full scale

DRIFT - $<\pm 2$ millivolts/°C for all discriminators

ANALOG-TO-DIGITAL CONVERTER

TYPE - Wilkinson

INPUT - a) 0 to 8 Volts Full Scale, with a 25% overrange for use with Digital Offset

b) Rise Time 0.1µs to 5µs

c) Fall Time 0.1µs to 10µs

d) Duration 1µs minimum

e) Input impedance 1000 ohms Direct Coupled

NONLINEARITY - Integral $<\pm .075\%$ over top 99% of Range; Differential $<\pm 0.9\%$ over top 99% of Range

STABILITY - Better than 150ppm/°C for both zero level and conversion gain. Less than .02% Shift in any 24 hour period with constant line voltage and temperature

DEAD TIME PER EVENT (avg.) - (4 + PW + 0.02n) µPW = Rise Time to Peak; n = Converted Address

GATE INPUT - The Coincidence Input pulse timing requirements are as follows: Coincidence pulses must be applied at least .5µs before the analog peak amplitude and remain for at least .5µs after TTL compatible Positive True

METER - Per cent of time that ADC is busy (ADC dead time)

CONVERSION GAIN - 3 position toggle switch selects either 512, 1024 or 2048 conversion gain for full scale

CONVERSION CLOCK - 50MHz crystal controlled

OFFSET - Rotary switch which may be used to select a digital offset of 0-1792 channels in 256 channel steps

ADC ZERO - 22-turn screwdriver adjustment on front panel; range approximately ±2% of full scale, resolution better than 0.01% of full scale

MEMORY

NUMBER OF CHANNELS - 1024 channels

COUNT CAPACITY - 10^6-1 per channel (10^8-1 for the integral channels 1022 & 1023)

TYPE - Semiconductor

CYCLE TIME - 1µs for a Read/Write CYCLE

CONTROLS

MEMORY - Selects memory group to be addressed and displayed, also sets digital range of the ADC (Internal jumpers will allow the ADC to be set external of this control). 1/1 enables use of total memory, 1/2 and 2/2 enables use of one half of memory. COMP. displays the second half over the first half with a fixed 20% offset

CLEAR-DATA - Will clear the selected memory group. Non-operative in Compare

CLEAR-ZERO - Will clear channel zero of the selected memory group

ARITHMETIC - Add or subtract data

MEMORY TEST - Internal switch adds (or subtracts) one count per MCSR sweep, when unit is started in MCSR

COLLECT FUNCTIONS

PULSE HEIGHT ANALYSIS (PHA)

TIME (CHANNEL 0) - 100KHz crystal controlled clock is gated off with the ADC dead time. The gated pulses are pre-scaled to one second and added to the contents of channel zero

PRESET - May preset on either the cursor counts, any count, or time. Preset Range from 10 counts to 900,000 counts. Setting a Preset of 0 will turn off the Preset Control

MULTICHANNEL SCALING (MCS)

MCS - Multichannel scaling may be performed with dwell times from 100µs per channel to 900 ms/channel expandable by factors of 10 and 100 by internal controls, with an average dead time the greater of either the pulse width or 3µs. The collect cycle will end after one sweep. Stopping the collect operation will stop MCS in the middle of a cycle. Channel zero will count the number of sweeps

MCSR - Same as MCS except will keep doing reoccuring sweeps. May be stopped at the end of a sweep by putting the unit back into the MCS mode

MINIMUM INPUT PULSE WIDTH - 50nsec

EXTERNAL MCS (Opt.) - Back panel BNC type connector optional

a) External MCS - A ground will put the unit into External MCS Mode

b) Start Dwell - A T^2L negative pulse of 1µs duration will start the Dwell Cycle

c) Channel Advance - A T^2L negative pulse of 1µs duration will advance the unit to the next channel

d) Channel Overflow when the Channel Advance overflows its count, a negative T^2L pulse of 10µs duration will be given

INPUT/OUTPUT

Standard I/O Interfacing is provided for TTY, EIA RS232C, and the Canberra Model 5411 Digital Cassette. Plug-in option cards are available for parallel printers and X-Y or T-Y Plotters.

Readout may be Full Memory, either Half, or Regions of interest only. Readin may be Full Memory or either Half. TTY I/O takes place at 110 Baud, EIA I/O selectable to 2400 Baud. Cassette I/O is 1200 Baud. TTY and EIA printouts are provided with alphanumeric labeling.

DISPLAY

CRT

SIZE - 9" diagonal

CONTROLS - Intensity

DATA DISPLAY

VERTICAL (RANGE) - Linear: 99; 999; 9,999; 99,999; 999,999 counts full scale

VERTICAL (GAIN) - X2 (provides full scale of 49, 499, 4999, 49999 or 499999 counts)

HORIZONTAL RANGE - Full or half memory

CHANNEL IDENTIFICATION - Cursor line vertical merker. Regions-of-Interest have histogram lines from zero to channel height

ALPHA-NUMERIC READOUT - Characters displayed on CRT in one line are: CL=XXXX, CC=XXXXXX, INT=XXXXXXXX where CL=Cursor Location, CC=Cursor Counts, INTG=Integral Counts

SCAN LEVEL CONTROL - Controls the position for the Cursor in normal & Expanded display. Controls the display roll when in Roll

REGION-OF-INTEREST (ROI) - INTEGRAL - When the Enter ROI switch is on, the cursor will paint in an ROI on its channel. There may be up to 510 regions of interest. Each ROI channel will have a vertical bar from the baseline to the vertical dot. The Integral will be that of the ROI the cursor is in or the one immediately to the right of the cursor. If there are no regions of interest to the right of the cursor, the integral of the last ROI will be displayed. In Expand, only the ROI contained in the Expanded Area will be integrated

ROI CLEAR ONE - Will clear one ROI to the right of the cursor. Non-operative if ROI Enter is on

ROI CLEAR ALL - Will clear all regions of interest displayed

INTEGRATE - With any ROI on the displayed channels, channels 1022 & 1023 will be used to store the value of the integral. The integral can range from 0 to 10^8-1 counts. If the cursor is put on either 1022 or 1023 when there is a single ROI on the display, preset of integral up to 900,000 counts can be made. (In 1/2, the cursor cannot be put into the integral channel for preset, in 2/2, the integral channels are 510 and 511)

EXPAND OFF; ON; ROLL - When activated, will place the cursor in the center of the Expanded Region and expand approximately 64 channels on either side of the cursor. In the ON position, the Scan Lever will move just the cursor; in Roll the cursor will stay fixed and the spectrum will roll by the display. When in Expand, channel zero will have a vertical line from 0 to full scale on the CRT to indicate the end or start of the spectrum, as the spectrum can roll through zero

PHYSICAL

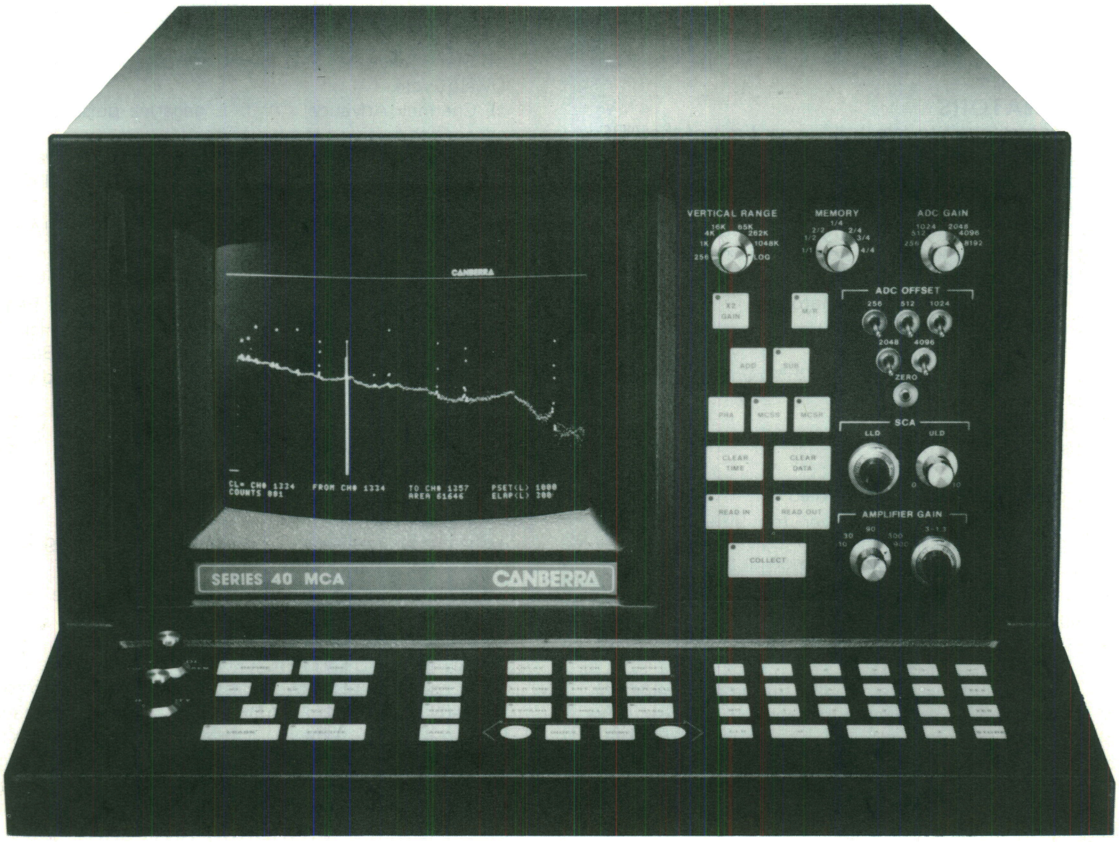
SIZE - Table top; 9 inches high, (22.86 cm) 16 in. wide, (40.64 cm) approximately 15 inches deep (38.1 cm)

WEIGHT - Approximately 30 lbs. (13.61 kgs)

POWER - 105 to 125 VAC or 210 to 250 VAC (Switch Selectable) Internal jumpers for 95 to 115 VAC or 190 to 230 VAC, 50 to 65 Hz, approximately 60 watts

OPERATING TEMPERATURE - 0 to 40°C ambient with adequate air flow

Series 40 Multichannel Analyzer



Features

- 1024, 4096, or 8192 Channel Memory capacity, 2^{20}-1 counts per channel
- 100 MHz, 8192 Channel ADC with DMA Interface
- 200 KHz or 20 MHz MCS (Option)
- Bipolar Amplifier, Charge or Voltage Input
- Plug-in HVPS or Spectroscopy Amplifier
- Simultaneous Data Acquisition, Display, and I/O
- 9 in. (Diagonal) CRT, Linear and Log Display Modes
- Integral, Net Area, Strip, Ratio, and Energy Calibrate for Spectrum Analysis
- Define/Use and Learn/Execute for Automatic Analysis
- Standard TTY/EIA/Cassette I/O Interface
- Online Computer Control via RS-232C, RS-422 or IEEE-488 Interfacing

Description

The Canberra Series 40 Multichannel Analyzer offers high performance data acquisition. CPU data analysis, and simultaneous I/O in one compact, cost-effective package. The Series 40 provides the performance needed for the research laboratory, the large CRT and ease of use needed for the classroom, and the flexibility required to fulfill a host of spectrum analysis applications.

For a single input system, the 4221 plug-in Amp/ADC provides a bipolar utility amplifier, 100 MHz ADC, and 200 kHz MCS. Add the model 4222 for high speed 20 MHz Multichannel Scaling. When more than one ADC is required, the model 4223 Multi-ADC Interface is the answer. Up to four (4) external ADCs—each with its own time base, presets, and Start/Stop control—can be controlled with the 4223. All data acquisition is via Direct Memory Access, providing maximum throughput regardless of mode.

A totally flicker-free 9 in. (23cm diagonal) raster scan CRT is provided for data analysis. Spectra may be displayed in either linear or log mode, along with alphanumeric text for dialogue and status information. Standard analysis functions include Integral. Net Area (with end point averaging). Fractional Spectrum Stripping, Ratio computation, and Digital Energy (or time) Calibration. Automating routine analytical procedures is greatly simplified by options such as Learn/Execute (Model 4242) and Define/Use (Model 4241), a unique Algebraic User Programming Facility.

The Series 40 provides an equally flexible Input/Output capability. A combination TTY/EIA/Cassette Interface is standard, and plug-in options can add serial printers, and X-Y or graphics plotters. An I/O can proceed simultaneously with data acquisition and display.

Description (continued)

For on-line computer control, the choices are equally impressive. Full Jupiter System Support is available via the RS-422 model 4273 interface. Or choose IEEE-488 (GPIB) Talker/Listener or RS-232C. All provide full MCA control and bidirectional data transfer.

The Canberra Series 40 MCA is all of the above, and more. It's compact, light-weight, and very affordable. A unique combination of performance, packaging, and price for essentially any spectrum analysis application.

Specifications

SIGNAL PROCESSING

4221 AMPLIFIER /ADC

AMPLIFIER - Bipolar Spectroscopy Amp with 1μsec shaping time constant.

INPUT - Charge or voltage sensitive, selected via internal jumper Factory set to voltage. BNC connector on side of bezel.

Charge - Negative pulses from decoupled scintillation photomultiplier or proportional counter; Full scale sensitivity 3.45 to 1333 picocoulombs (minimum to maximum amp gain); maximum dc input ±100 volts; Input impedance ≈470 ohms.

Voltage - Positive or negative tail pulses from an associated preamplifier; 0 to ±12 volts maximum; 0 to ±3.3 volts for linear range; rise time <1μsec; decay time 40 to 60μsec; input impedance ≈1k ohms.

OUTPUT - 0 to +10 volt linear bipolar output derived using a 5th order filter network. Shaping time constant of 1μsec.; switch selectable as input to ADC.

FRONT PANEL CONTROLS

COARSE GAIN - Five position rotary switch selects gain factors of x 10, x 30, x 90, x 300, and x 900.

FINE GAIN - Ten-turn locking dial precision potentiometer selects variable gain factor of x 0.3 to x 1.3; resetability <0.05%.

INTERNAL CONTROLS

MODE - Jumper plug allows the AMP IN connector to accept charge or voltage inputs. Shipped in the VOLTAGE mode.

POLARITY - Jumper plug sets the amplifier for the polarity of the incoming preamplifier signal (voltage mode). Shipped in the POSitive position.

POLE/ZERO - Single-turn screwdriver adjustable pole/zero potentiometer to optimize amplifier baseline recovery and overload performance for the voltage mode input fall-time constant; pole/zero range; 40 to 60μsec. Factory set to 50μsec.

PERFORMANCE

GAIN RANGE

Charge Mode - Continuously variable from 7.5 mV/pC to 2.9 V/pC, product of COARSE and FINE GAIN Controls.

Voltage Mode - Continuously variable from x 3 to x 1170, product of COARSE and FINE GAIN Controls.

GAIN DRIFT - <±0.01%/°C (±100 ppm/°C)

DC DRIFT - <±50μV/°C

INTEGRAL NONLINEARITY - <±0.05% over full dynamic output range.

OVERLOAD RECOVERY - Output recovers to within ±1% of full scale output from x 500 overload in 20μsec.

SHAPING - Bipolar; 1μsec.

NOISE -

Charge Mode - 4.75 x 10^{-15} coulombs RMS referred to input at maximum gain and 0 pF input capacitance.

Voltage Mode - 14μV true RMS referred to input at maximum gain.

Count Rate Stability - the peak position of a ^{60}Co 1.33 MeV gamma peak for an incoming count rate of 2 kcps to 100 kcps and a 9 volt pulse height will typically shift less than 0.08%.

ADC-100 MHZ WILKINSON TYPE

INPUTS -

SIGNAL INPUT - Direct coupled from internal or external amplifier via switch on the bezel, 0 to +10 volt full scale; diode clamped for input protection at +12 and -0.6V; rise time 250 nsec minimum and 100μsec maximum in PHA mode, or dc level in SVA mode; impedance ≈1k ohms; external Amp In BNC mounted on side of Bezel.

GATE INPUT - TTL logic pulse or level, +2.5 to +5.5V; width >250 nsec, dc coupled; <2 mA loading; Bezel mounted BNC; PHA Mode - late coincidence standard. Positive or open input during time to peak of pulse (Linear gate period) will enable conversion and storage of pulse; ground level will cause pulse to be rejected. Internal jumper provided for selecting late AntiCoincidence operation. Sampled Voltage Analysis (SVA) Mode - GATE used as sampling signal; mode selected by internal jumper. In MCS mode, the GATE signal enables counting.

MIXER/ROUTER - Model 4231 Mixer/Router Wiring provides all signals necessary for use with Canberra Mixer/Router 8220A; 25-pin rear panel connector.

PILEUP REJECTOR/LIVE TIME CORRECTOR - Model 4234 provides all signals necessary for use with Canberra Model 2013, 2020 or equivalent PUR/LTC amplifier; rear panel BNC (DT) and 3-pin Molex connectors.

OUTPUT

STABILIZER - Model 4233 Digital Stabilizer Wiring provides all signals necessary for use with Canberra Model 8200 Digital Stabilizer; 25-pin rear panel connector.

FRONT PANEL CONTROLS AND INDICATORS

CONVERSION GAIN - Six position rotary switch to select full scale resolution of input signal; selection of 256, 512, 1024, 2048, 4096 or 8192 channels per 10 volt input.

CONVERSION RANGE - ADC overflow normally set by position of memory control when starting collect; 256, 512, 1024, 2048, 4096 or 8192 channels.

DIGITAL OFFSET - Five toggle switches to provide suppression of digital zero, 0 to 7936 channels in increments of 256 channels; with an ADC conversion gain of 512 the indicated offset is divided by 2; with gain of 256 it must be divided by 4.

ADC ZERO - 22-turn screwdriver adjustable pot to vary analog zero; range ±5% of input range.

LOWER LEVEL DISCRIMINATOR (LLD) - Ten-turn locking dial precision potentiometer; sets lower limit of ADC window; range 0 to >105% of full scale; resolution and resetability <0.05%.

UPPER LEVEL DISCRIMINATOR (ULD) - Single-turn pot; sets upper limit of ADC window; range 0 to >105% of full scale.

% DEAD TIME - Percent time ADC is busy in PHA Collect, displayed via bar graph on CRT during data acquisition.

INTERNAL CONTROLS

GATE - Jumper plug to select Coincidence or Anticoincidence gating for PHA and MCS; Factory set to Coincidence.

MODE - Jumper plug to select PHA or SVA; Factory set to PHA.

MIXER-ROUTER - DIP plug to correspond to memory and mixer/router; provided with Model 4231.

THRESHOLD - Single-turn pot; sets triggering level of ADC; factory set to ≈50 mV.

GAIN - Single-turn pot; sets current for Wilkinson discharge ramp.

PERFORMANCE

CONVERSION TIME - Linear Gate Period + 0.01 (N+X) μsec + 3μsec.

Where Linear Gate Period starts when the input pulse crosses the threshold level and ends when the Constant Fraction Peak Detector closes the gate after the peak roll-over at ≈90% of peak value.

N = Address

X = Effective Digital Offset

For Conversion Gains of 512 or 256 the (N+X) value must be multiplied by 2 or 4, respectively.

NON-LINEARITY -

Integral - <±0.025% of full scale over the top 99% of the full scale Conversion Gain Range.

Differential - <±1% over the top 99% of the Conversion Gain Range.

DRIFT - (of full scale Conversion Gain Range)

Zero - <±25 ppm/°C

Gain - <±100 ppm/°C

Long Term - <50 ppm/24 hrs. at constant ambient temperature

PEAK SHIFT - <±0.025% of full scale at rates to 50 kHz.

MCS MODE - ADC logic used for pulse selection. PHA type Add/Sub one cycle used to modify memory at current MCS address.

Count Rate - Accepts all inputs to 65 kHz with 1μs pulse width (15μs pulse pair resolution). Above this pulses will be lost. At 200 kHz for 1μs wide pulses.

EXPAND - 99% of pulses stored

4K or 8K - 85% of pulses stored

Dwell Time - 110μsec minimum to 9 hours maximum

External Control - via Model 4232 External Control Wiring Option

Specifications(continued)

PHYSICAL - Plug-in PC Card, mutually exclusive with Model 4223

4222 20 MHZ MCS

INPUT - Positive TTL Logic pulse via a rear panel BNC supplied as part of the requisite Model 4232 External Control Wiring. Input loading less than 1 mA; Provision for 50 ohm termination at receiver.

PERFORMANCE

Count Rate - 20 MHz (50 nsec pulse pair resolution minimum)

Dwell - 10μsec minimum to 9 hours maximum per channel

Dead Time - <300 nsec per dwell time

Gating - Gate input used. Coincidence or anti-coincidence; jumper selectable.

PREREQUISITE - Model 4232 External Control Wiring

PHYSICAL - Plug-in PC Board option

4223 MULTI-ADC INTERFACE

INPUTS - 1 to 4 external Canberra ADCs via rear panel Amphenol connectors

CONTROL - Individual Start/Stop, Time Base, and Presets for each ADC via front panel control

ROUTING - 1, 2, or 4 ADCs are routed to Full, Halves, or Quarters of Memory, respectively.

MCS - Requires 4222 and 4232

PHYSICAL - Plug-in PC Board, mutually exclusive with Model 4221

4232 EXTERNAL CONTROL WIRING

INPUTS - MCS Channel Advance, MCS Sweep Trigger, Abort MCS Sweep, Gate, Sample Changer Busy, Start Collect, Stop Collect, Start Readout, Clear Data

OUTPUTS - Sample Changer Advance, Busy, Collect Status, I/O Status, MCS End of Sweep.

PHYSICAL - Rear panel Amphenol connector

PROCESSOR

DATA MEMORY - 1024, 4096, or 8192 Channels, 2^{20}-1 counts per channel, divisible into Halves or Quarters. Semiconductor, with optional battery backup 600 nsec processor memory cycle time.

STORAGE MODES - PHA, MCS, and MCSR. Choice of Add or Subtract storage.

PRESETS

PHA - Choice of Live Time, True Time, Counts in a Channel, Integral of an ROI, Net Area of an ROI, or USE function.

MCS - Dwell Time per Channel and (MCSR only) number of sweeps.

DISPLAY

CRT - 9 in. (23 cm diagonal) raster-scan type, with DMA interface. Totally flicker-free.

Data Display - Linear and Log vertical scales with intensified points for Regions of Interest and histogram bars for Area. Single digitally-controlled Cursor. Horizontal (128 channel) and Vertical (x2) Expansion. Spectrum Overlap. Vertical Range set by Rotary switch at 256, 1K, 4K, 16K, 65K, 262K and 1048K full scale. Vertical resolution 1 part in 256. Log conversion via table look-up, accurate within display resolution. Horizontal resolution 1 part in 1024; automatic horizontal compression for >1024 data points.

Character Display - 2 lines of Alphanumerics, 64 characters per line

% Dead Time - Moving bar % Dead Time whenever PHA Collect is active

ANALYSIS FUNCTIONS

STANDARD FEATURES -

TRANSFER - from any Half or Quarter to any Half or Quarter

OVERLAP - any Half or Quarter over any Half or Quarter

INTEGRAL - Full Memory or Regions of Interest

NET AREA - Full Memory or Regions of Interest; End Point Averaged

FRACTIONAL SPECTRUM STRIPPING - Any Half or Quarter from any Half or Quarter; Factor range $-327.675 \leqslant F \leqslant +327.675$; Normalization via stripping a region from itself using a negative factor.

RATIO COMPUTATION - Dynamically computes and displays the ratio between the counts in any two channels, the integral of any two ROIs, or the net area of any two ROIs.

ENERGY CALIBRATION - Two point calibration with a choice of EV, KEV, MEV, MSEC, SEC, or MIN for the calibration units.

OPTIONS -

4241 DEFINE/USE - Provides Algebraic User Programming. Up to four equations may be defined, where each equation may consist of

1. Numeric Literals
2. Two defined Constants
3. Two Variables
4. Live Time
5. The Operators +, -, x, ÷, √, (,), and 10^N (EEX)

The Variables can be defined to be

1. Channel Number (or Energy) of the Cursor
2. Counts in a specific (or Cursor) Channel
3. Integral of a specific (or Current) ROI or Full Memory
4. Net Area of a specific (or Current) ROI or Full Memory
5. The value of another equation

Parenthetical Nesting to four levels is provided, and all computations are performed in Floating Point Arithmetic. An Equation Load/Save facility is provided, using either cassette or paper tape I/O.

Once an equation has been defined and activated, its current value is displayed on the CRT and may be included in Readout Reports. In addition, a summation facility is provided for recording cumulative results.

4242 LEARN/EXECUTE - Provides a means of entering and executing automatic analytical sequences. Up to four sequences may be defined, but only one may be executed at a time. A sequence Load/Save facility is provided, using either cassette or paper tape I/O.

INPUT/OUTPUT

STANDARD - Combination TTY (Current Loop), EIA RS-232C, and 5411 Digital Cassette I/O Interface. Both ASCII and Binary data formats are supported. Data I/O may be either Full Memory or ROIs only, and is fully compatible with the Series 80 MCA. Series 30 data formats may be read in only. Both Manual and Recycle I/O controls are provided (Recycle is superseded by Model 4242 Learn/Execute, if it is present).

OPTIONS - Two I/O slots are provided and may be used for any two of the following:

a. Model 4251 X-Y Plotter or Model 4253 Graphics Plotter Interface

b. Model 4252 Serial Printer/Plotter Interface

c. Computer Control Interface:
Choice of RS-232C, RS-422, or IEEE-488. Full Jupiter software support is available for the model 4273 RS-422 Interface.

REAR PANEL CONNECTORS

STANDARD -

TTY - 9-pin

EIA - 25-pin; connects to Model 5411 or EIA RS232C Compatible peripheral

STANDBY POWER - 15-pin

PREAMP POWER - 9-pin

HVPS POWER - 3-pin Molex (connects to Model 4261)

NIM - type slot for Detector Bias Supply (Model 3100-01) or Spectroscopy Amplifier (Model 3100-02)

OPTIONS

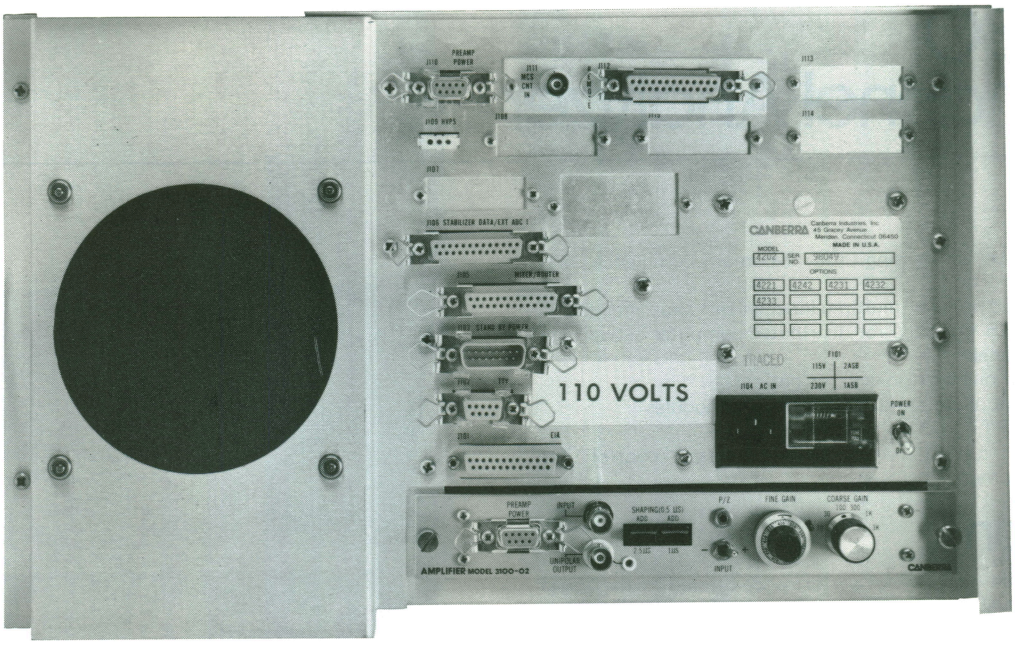
MIXER/ROUTER - 25-pin, Model 4231

REMOTE CONTROL - BNC and 25-pin, Model 4232

DIGITAL STABILIZER - 25-pin, Model 4233

PUR/LTC - BNC and 3-pin Molex Model 4234

BOLT-ON 5 kV HVPS - Model 4261



Specifications(continued)

PHYSICAL

SIZE - 26.7 cm high (10.5 in.) x 44.5 cm wide (17.5 in.) x 61 cm deep (24 in.)

WEIGHT - Approximately 19.5 kg (43 lbs.)

SHIPPING WEIGHT - 24 kg (53 lbs.)

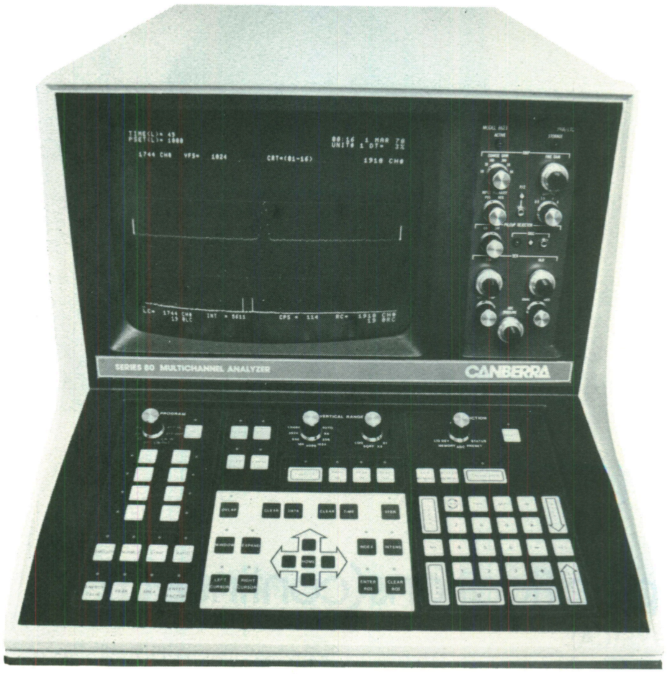
POWER - 105 to 125V ac or 210 to 250V ac or 95 to 115V ac or 190 to 230V ac, Rear panel jumper plug selectable 50 or 60 Hz, approximately 110 watts

OPERATING TEMPERATURE - 0 to +45°C with adequate airflow for fan at rear.

Series 80
Multichannel Analyzer

Features

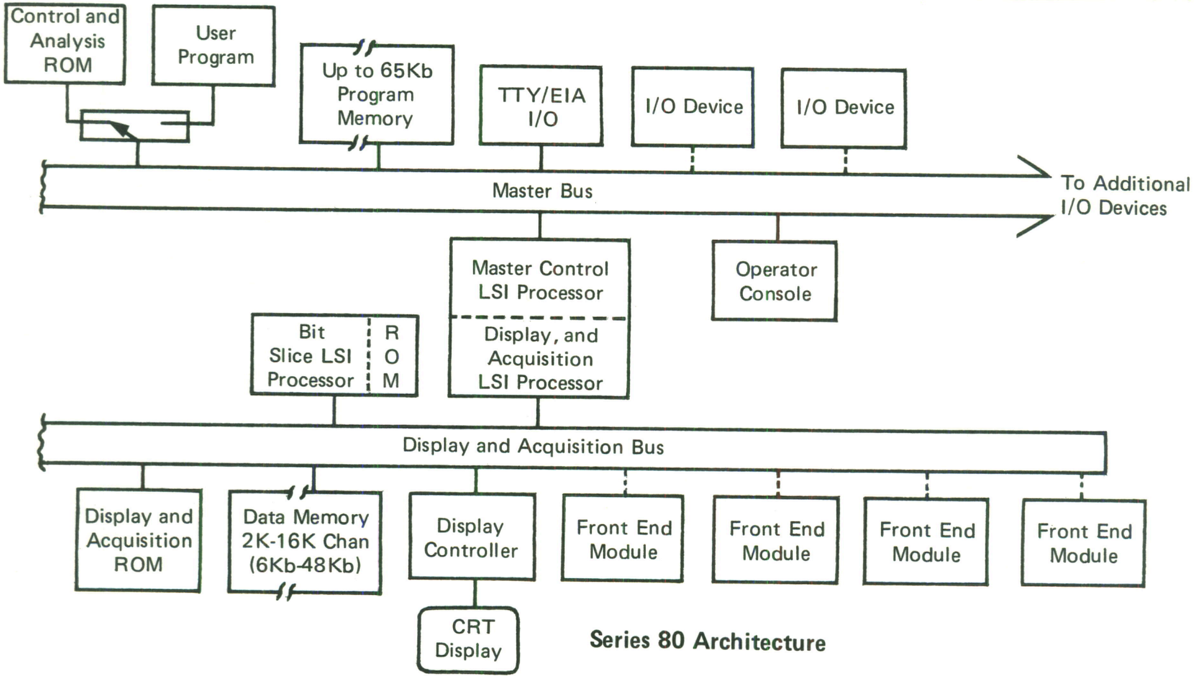
- True distributed processing for maximum efficiency and throughput
- Multi-tasking software for multiple independent experiments
- On-line JUPITER interface for distributed computer networking
- 2K to 16K channels
- Complete set of pushbutton analysis options
- Choice of four application-tailored front end modules
- 12" diagonal CRT
- Learn/Execute option with sample changer control for completely automatic analyses


SERIES 80 MULTICHANNEL ANALYZER
CANBERRA

Description

A key ingredient to the high level of performance offered by the Series 80 is its unique dual bus structure. Two independent tristate buses—each with a 660 nanosecond cycle time—provide an unmatched throughput capability. One bus is devoted to Data Acquisition and Display; the other to Analysis and I/O. An ideal architecture for efficient, simultaneous operation.

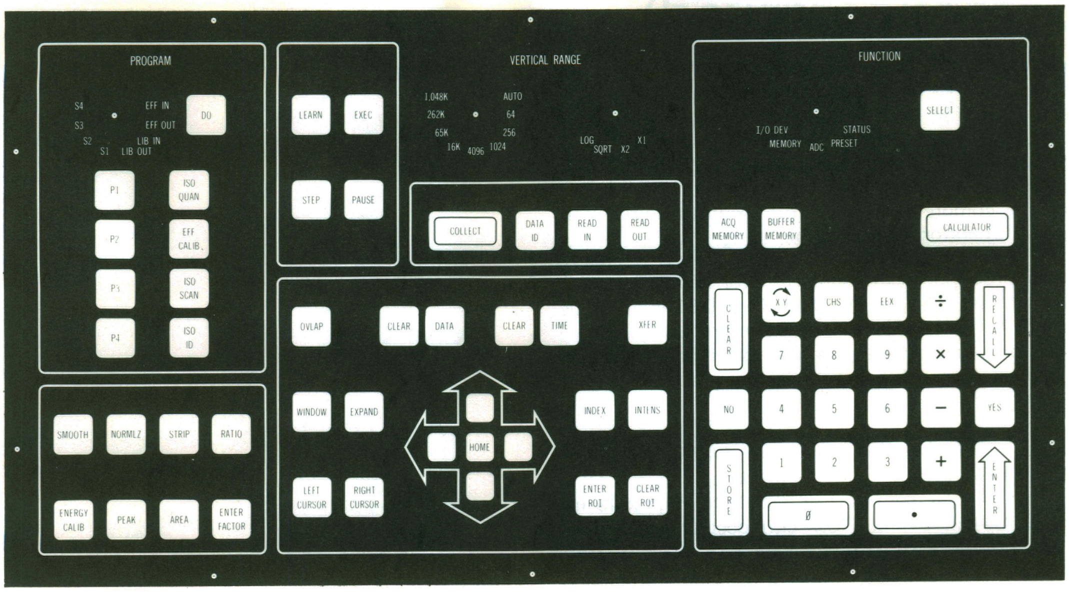
Three independent microprocessors—each assigned to its own specific task—ideally complement the Series 80 bus structure. A true distributed processing network provides each major MCA function with the processing power required for optimum system performance.


Control and Analysis ROM
User Program
Up to 65Kb Program Memory
TTY/EIA I/O
I/O Device
I/O Device
Master Bus
To Additional I/O Devices
Master Control LSI Processor
Display, and Acquisition LSI Processor
Operator Console
Bit Slice LSI Processor
R O M
Display and Acquisition Bus
Display and Acquisition ROM
Data Memory 2K-16K Chan (6Kb-48Kb)
Display Controller
CRT Display
Front End Module
Front End Module
Front End Module
Front End Module

Series 80 Architecture

And it's all tied together with a Multi-tasking operating system to ensure that the full power and capabilities available can be readily applied to solve your specific application problems.

All Series 80 MCA functions—from basic picture control to Quantitative Isotopic Analysis—are controlled from the unique "Touchpanel" Operator's Console. This console provides dust-free switch contacts for years of trouble-free operation in which a definite positive manual action is required, and for which an audible "click" is provided to indicate contact. Critical functions, like clear data and clear time, require simultaneous pressing of two buttons to prevent accidental clearing. For many functions, a further level of safeguard is provided by requiring operator response to dialog on the CRT. Standard control functions include all display manipulation, including display range, dual cursor positioning, multiple regions of interest, ADC, memory, and input/output setup, and a four-function calculator. These occupy the center and right portion of the console. Options available as plug-in ROM include energy calibration and automatic peak search, spectrum stripping, isotope identification, quantitative isotopic analysis, and learn/execute. Console panel buttons for these options are located on the left side of the console, plus additional unused buttons reserved for user programming.


PROGRAM
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S3
S2
S1
EFF IN
EFF OUT
LIB IN
LIB OUT
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P1
P2
P3
P4
ISO QUAN
EFF CALIB
ISO SCAN
ISO ID
SMOOTH
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STEP
PAUSE
VERTICAL RANGE
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65K
16K
4096
1024
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X2
X1
COLLECT
DATA ID
READ IN
READ OUT
OVLAP
CLEAR
DATA
CLEAR
TIME
XFER
WINDOW
EXPAND
HOME
INDEX
INTENS
LEFT CURSOR
RIGHT CURSOR
ENTER ROI
CLEAR ROI
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I/O DEV
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Finger Tip Touchpanel Control

Specifications

FRONT END MODULES (Signal Processing and ADC, MCS)

8621 ADC/SCA - 100MHz Wilkinson type ADC with full 8192 channel conversion gain. Independent SCA output. Full program control of Conversion Gain, Range, and Digital Offset. DMA mode for data storage. Integral Nonlinearity <±0.025% over 99% of full scale.

8622 PHA/MCS - spectroscopy amplifier with Gated Active BLR, 20MHz MCS input. 100MHz x 8192 channel ADC. External or Program Control for MCS operation; 50 nanosecond pulse pair resolution; <250 nanosecond dead time between channels; Up/Up and Up/Down modes. DMA data storage.

8623 PHA/LTC - spectroscopy amplifier with variable shaping time constants and Gated Active BLR. Leading and Trailing Edge Pulse Pileup Rejector with Live Time Correction. 100MHz ADC with 8192 channel conversion gain. Full program control with DMA data storage.

8624 ADC/MR - four input Mixer/Router with individual linear gates for each input. Separate Live and True Timers for each input. 100MHz ADC with 8192 channel conversion gain. Full program control with DMA data storage.

8633 EXTERNAL ADC INTERFACE - provides interface and control for Canberra external ADCs Models 8070, 8070A and 8080. Conversion gain is set on the external ADC.

Expansion to 2, 3, or 4 Front End Modules is provided by the Model 8683A Expansion Chassis.

MODEL 8600 PROCESSOR

MEMORY

NUMBER OF CHANNELS - 2048, 4096, 8192 or 16,384

- **Model 8602** - 2048 Channels
- **Model 8603** - 4096 Channels
- **Model 8604** - 8192 Channels
- **Model 8605** - 16,384 Channels

COUNT CAPACITY - 2^{20} -1 (1, 048, 575).

TYPE - Semiconductor.

CYCLE TIME - 660 nanoseconds.

CONTROLS

MEMORY - memory group accessed by ADC and memory range displayed are independently set up. ADC memory range is 256 to 8192 channels; display range is 256 to 16,384 channels. Memory overlap provides simultaneous display of any two regions of memory of equal or unequal size.

CLEAR DATA - will clear displayed memory group unless operator selects a different memory region. Requires operator confirmation before clear occurs.

CLEAR TIME - will clear live and true time of displayed memory group or operator selected group. Requires operator confirmation before clear occurs.

TRANSFER - transfer of any group to any other equal size group of channels.

ADC - programmable conversion gain (256, 512, 1024, 2048, 4096 or 8192), digital offset (0 to ±9999 in 1 channel increments), range (256 to 8192), and add, subtract or list.

MCS (Unit 8622 PHA/MCS only) - programmable dwell time (10 microseconds to 9 hours per channel), range, add or subtract, and up/up or up/down. Count capacity of 2^{20}-1 counts for dwell times greater than 1 millisec, 2^{16}-1 for shorter dwell times. Internal or external control (of sweep trigger, channel advance, and stop).

PRESET - may be set on true or live time, counts in a specific channel, overflow of any channel, or integral of a specific region (up to 2.147 x 10^9 counts). If option 8641 is present, preset on net area in a region or the statistical error of net area may be set.

DISPLAY

CRT - 12″ (30.5cm) diagonal with separate intensity controls for spectrum and alphanumerics, and for graticule.

MODE - linear, log, or square root, with autoranging capability for linear and square root display.

VERTICAL RANGE - 64 to 1,048,576 (linear or square root) plus X1 or X2, and 2^0 to 2^{20} (log).

HORIZONTAL RANGE - 256 to 16,384 channels, in binary increments.

CHANNEL IDENTIFICATION - dual cursors, movable separately or together, with location and channel contents indicated on CRT.

REGION-OF-INTEREST (ROI) - entered between the cursors when ENTER ROI is pressed; indicated by overintensification of channel data. CLEAR ROI clears region-of-interest between cursors.

INTEGRAL - sum of counts between cursor is displayed at all times.

CPS - counts per second of region between cursors is displayed at all times.

% DEAD TIME - displayed at all times for displayed ADC or for ADC selected by left cursor if multiple spectra are displayed.

TIME, DATE - 24 hour clock (hours, minutes) and Julian calendar date are displayed.

EXPAND - region between cursors is displayed above the full spectrum, expanded to full width of display. Amount of expansion or movement of expanded region is controlled by turning on WINDOW and cursors off or on.

ANALYSIS OPTIONS (field installable)

8641 - provides Digital Energy Calibration, Peak Net Area and Peak Centroid Location. Includes choice of calibration units and true peak search capabilities.

Specifications(continued)

8642 - includes Spectrum Smoothing, Spectrum Normalization, Ratio Computation, and Fractional Spectrum Stripping.

8643 - provides pushbutton isotope identification from built-in or user defined libraries. Requires Model 8641 for operation.

8644 - includes Detector Efficiency Calibration and Quantitative Isotopic Analysis. Requires Models 8641 and 8643 for operation.

8645 - provides a comprehensive Learn/Execute facility with Sample Changer and Operator Pause control.

INPUT/OUTPUT

TERMINAL - basic processor includes interface for standard current loop terminals such as Teletype, Model 33 or DECwriter, plus terminal oriented EIA Interface, 110 to 9600 baud rate.

OPTIONAL I/O - plug-in interfaces are available for X-Y plotter, graphics plotter, dual floppy disk, magnetic tape, paper tape, and line printer.

PHYSICAL

SIZE - Freestanding (Table Top) unit—Standard: 14.5 in. (36.8 cm) high x 18 in. (45.7 cm) wide x 31 in. (78.7 cm) deep.

Rack Mounting Unit — optional; 14.0 in. (35.6 cm) high x 19 in. (48.3 cm) wide x overall 31 in. (78.7 cm) deep; chassis slides provided.

The rack mounting unit requires 20.4 in. (51.8 cm) of depth behind panel not including clearances for external cables.

WEIGHT - freestanding. Net—90 lbs. (40.9 kg).
Shipping—125 lbs. (56.8 kg).
Rack Mounting, Net—82 lbs. (37.3 kg).
Shipping—117 lbs. (53.2 kg)

POWER REQUIREMENTS

105 to 125VAC or 210 to 250VAC Switch selectable; 50 to 65Hz; ≈250 watts; Low Line voltage tap internally selected 95/190 VAC nominal.

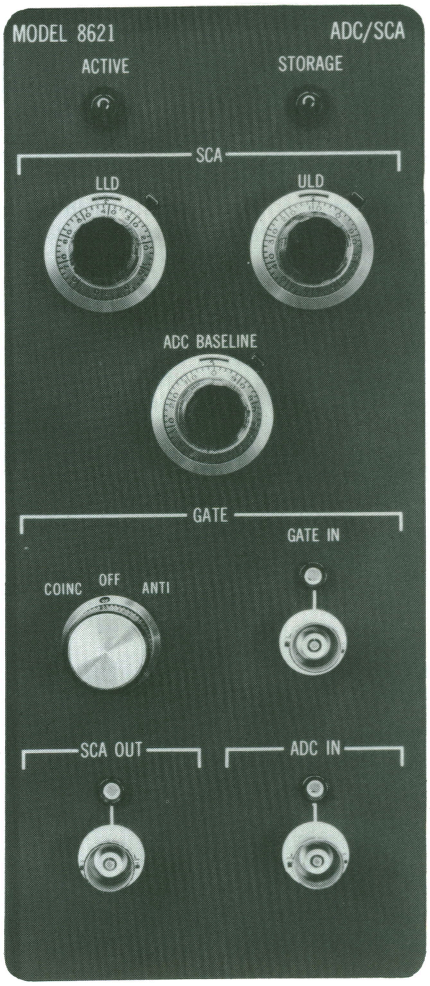
OPERATING TEMPERATURE

0 to +45°C with adequate air flow for fan on side.

Model 8621
ADC/SCA

Features

- 100 MHz Wilkinson ADC with 8192 channel conversion gain
- Conversion gain and range programmable from 256 to 8192 channels in binary increments
- Digital offset programmable in one channel increments from 0 to 8191 channels
- Independent SCA output
- Both live time and true time clocks
- Channel profile flat over >80% of channel width at 8192 gain
- Direct memory access (DMA) data storage with >2.5 µsec transfer time
- Compatible with Canberra Series 80 MCA and Model 8683A Expansion Chassis
- CRT display of % dead time



Description

The Model 8621 ADC/SCA is a plug-in signal processing module for the Canberra Series 80 family of Multichannel Analyzers. The 8621 occupies a single Front End Module (FEM) slot, and may be mounted in either a Series 80 mainframe chassis or the Model 8683A Expansion Chassis.

Functionally, the 8621 provides a 100MHz Wilkinson ADC, an independent SCA, and a DMA interface to the Series 80 Display and Acquisition Bus. The ADC Conversion Gain, Range, and Digital Offset are all program selectable via the Series 80 Display and Acquisition Processor. PHA Data Storage is via Direct Memory Access.

Both Live Time and True Time clocks are provided, with the times being stored in Channels 0 and 1, respectively. The ADC interface also provides for PHA mode selection (Add vs. Subtract), channel overflow interrupts, and program controlled data transfers for Digitize and List operation.

In addition to providing low cost, high performance PHA data acquisition, the Model 8621 also serves as the base upon which the 8622 PHA/MCS, 8623 PHA/LTC, and 8624 ADC/MR Front End Modules were built. A Series 80 MCA system can be expanded to include up to four (4) of these FEM's in any combination.

Specifications

INPUTS

ADC IN - Positive Unipolar, Bipolar (Pos. Leading), or dc Levels; 0 to +10V. Rise Time >250 nsec; Width 1 µsec min to 30 µsec max (longer on request). $Z_{in} \approx 1.2$k ohms, dc Coupled. Front and Rear Panel BNC's, Front Panel Test Point

GATE IN - Positive Logic Pulse or Level, +2.5 to +8.5V; Width >100 nsec, dc Coupled; Front and Rear Panel BNC's, Front Panel Test Point

OUTPUTS

SCA OUT - Positive logic pulse generated when input falls through the LLD. Width $\approx$0.5µsec; $Z_{out} \approx 50$ ohms. Front and Rear Panel BNC's, Front Panel Test point

FRONT PANEL CONTROLS

LLD - Ten-turn locking pot; 0 - 110% of input

ULD - Ten-turn locking pot; 0 - 110% of input

ADC BASELINE - Ten-turn locking pot; ±6% of full scale

GATE - Three position Rotary Switch. Selects Coincidence or Anticoincidence Gating; Off position disables gate. Internal jumpers for Early or Late Coincidence and Sample Voltage Analysis. Factory set to Late Coincidence

INDICATORS

ACTIVE - LED; indicates the 8621 has been enabled to take data.

STORAGE - LED; indicates that a conversion has been stored

PROGRAM CONTROLS

ADC GAIN - 256 to 8192 channels in binary increments

ADC RANGE - 256 to 8192 channels in binary increments

DIGITAL OFFSET - 0 to 8192 channels in increments of 1 channel

PERFORMANCE

SCA

INTEGRAL NON-LINEARITY - <±0.25% of full scale

RESOLUTION - <±0.05% of full scale

DRIFT - <±0.05% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature

PULSE PAIR RESOLUTION - 1µsec minimum

OFFSET FROM ADC WINDOW - <±0.5% of full scale

Specifications(continued)

ADC

INTEGRAL NON-LINEARITY - <±0.025% of full scale over top 99% of range

DIFFERENTIAL NON-LINEARITY - <±1% over top 99% of range

DRIFT

Gain - <±0.01% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature
Zero - <±0.01% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature

COUNT RATE SHIFT - <±0.025% of full scale at rates up to 50kHz.

CONVERSION TIME - 2.5 +0.01 (N + X)μsec, where N = Converted Value and X = the amount of Digital Offset. Multiply (N + X) by 2 and 4 for 512 and 256 gain, respectively

CHANNEL PROFILE - On 8192 gain, flat over >80% of width; on other gains flat over >90% of channel width

TIME BASE - Live and True Time stored in channels 0 and 1, respectively. Live Time gated with a 1MHz crystal controlled clock and prescaled to 1 second increments of memory

PHYSICAL

Occupies one FEM position in an 860X Processor or 8683A Expansion Chassis

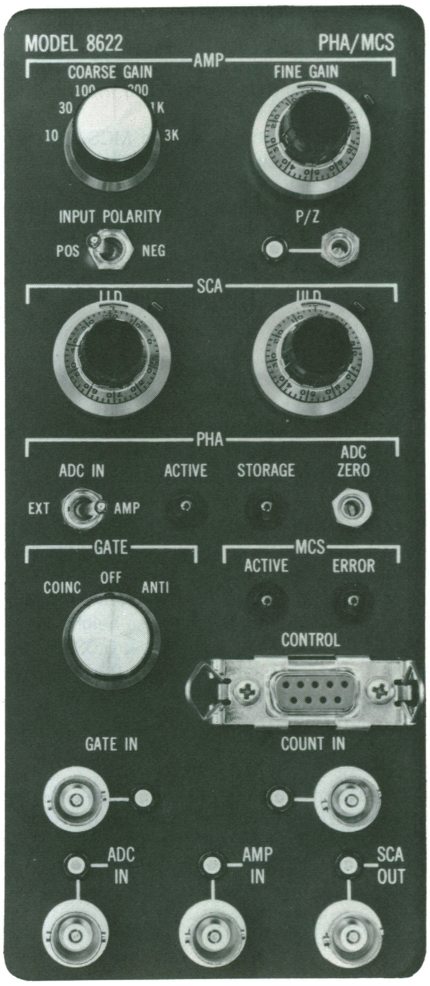
OPTIONS

ADC slot in the 860X Processor or 8683A Expansion Chassis can be wired for use with 8200 Digital Stabilizer. Specify 8625 or 8626 for the 860X or 8683A respectively. This will allow stabilization of the Gain and/or zero by changing the ADC gain and/or zero. The amount of change possible is ≈±1%.

Model 8622
PHA/MCS

Features

- Spectroscopy amplifier with gated active baseline restorer
- 100MHz Wilkinson ADC with 8192 channel conversion gain
- Programmable conversion gain, range, and digital offset
- Independent SCA output
- 20MHz MCS input count rate
- <250 nanosec deadtime per dwell period
- UP/UP and UP/DOWN sweep modes
- Preset sweep count for recurring sweep operation
- Both program and external MCS control



Description

The Model 8622 PHA/MCS is a plug-in signal processing module for the Canberra Series 80 family of Multichannel Analyzers. The 8622 occupies a single Front End Module (FEM) slot, and may be mounted in either a Series 80 mainframe chassis or the Model 8683A Expansion Chassis.

Functionally, the 8622 provides a spectroscopy amplifier, independent SCA, 100MHz ADC, and 20MHz MCS unit - together with all necessary system interfacing - in a single plug-in module. The interface provides operating mode selection, DMA data storage, and full ADC and MCS control.

When operating in PHA mode, Live Time is stored in Channel 0 and True Time in Channel 1. Channel 0 is used as a Sweep Counter during MCS operation. For the ADC, program control is provided for Conversion Gain, Range, and Digital Offset. During MCS operation, the program controls Range, Sweep Mode (UP/UP vs. UP/DOWN), and the Sweep Preset. Dwell Time, Sweep Start, and Collect Stop may be either program or external event controlled.

The system interface also provides for PHA mode selection (Add or Subtract), channel overflow interrupts and program controlled data transfers for Digitize and List operation.

The 8622 PHA/MCS is one of several signal processing FEM's available for the Series 80 MCA. The Series 80 system can be field expanded to a total of four independent FEM's.

Specifications

INPUTS

ADC IN - Positive Unipolar, Bipolar (Pos Leading), or dc Levels; 0 to +10V. Rise Time >250 nsec; Width 1 μsec min to 30 μsec max (longer on request). $Z_{in} \approx 1.2$k ohms, dc Coupled. Front and Rear Panel BNCs, Front Panel Test Point

GATE IN - Positive Logic Pulse or Level, +2.5 to +8.5V; Width >100 nsec, dc Coupled; Front and Rear Panel BNCs, Front Panel Test Point

AMP IN - Positive or Negative linear pulses. Amplitude 0 to 12 volts max; 0 to3.2 volts for a linear output. $Z_{in} \approx 1$k ohms; Rise Time <3 μsec; Decay Time Constant 30 μsec to ∞. Front and Rear Panel BNCs, Front Panel Test Point

COUNT IN - MCS count input. Positive Logic Pulse, 2.5 to 8V; Width >25nsec. Pulse Pair Resolution >50nsec. Front Panel BNC and Test Point.

EXTERNAL SWEEP TRIGGER INPUT - When signal is connected a positive logic pulse (2.5 to 8V) is required to start a sweep; Width 0.5μsec to total sweep time. On Front Panel Control Connector.

EXTERNAL ADVANCE INPUT - When External Advance is enabled a positive logic pulse (2.5 to 8V) is required to advance the address counter; Width ≥0.5μsec. On Front Panel Control Connector

COLLECT STOP INPUT - Positive Logic Pulse (2.5 to 8V) stops acquisition at the end of the current MCS sweep. Width >0.5μsec. On Front Panel Control Connector.

OUTPUTS

SCA OUT - Positive Logic Pulse generated when input falls through the LLD. Width ≈0.5μsec; $Z_{out} \approx 50$ ohms. Front and Rear Panel BNCs, Front Panel Test Point

SWEEP TRIGGER OUT - Positive Logic Pulse generated at the start of each MCS sweep. Width ≈10 μsec. Z_{out} Logic 1 = 1k ohms; Logic 0 = sink 8 mA. On Front Panel Control Connector

FRONT PANEL CONTROLS

AMPLIFIER

COARSE GAIN - Six position rotary switch with factors of X10, X30, X100, X300, X1000, X3000

FINE GAIN - Ten-turn Locking Pot with range of X0.3 to X1

POLE ZERO - 22-turn screwdriver adjustment

INPUT POLARITY - Two position Toggle Switch selects Positive or Negative Input

SCA

LLD - Ten-turn Locking Pot; 0 - 110% of Input

ULD - Ten-turn Locking Pot; 0 - 110% of Input

Specifications(continued)

ADC

ADC IN - Two position Toggle Switch to select the internal or an external amplifier as the ADC and SCA input

ADC ZERO - 22-turn screwdriver adjustment; ±6% of full scale

GATE - Three position Rotary Switch. Selects Coincidence or Anticoincidence Gating; Off position disables gate. Internal jumpers for Early or Late Coincidence and Sample Voltage Analysis. Factory set to Late Coincidence

INDICATORS

PHA ACTIVE - LED; indicates that the module has been enabled for PHA acquisition

PHA STORAGE - LED; indicates that a PHA event has been stored

MCS ACTIVE - LED; indicates that the module has been enabled for MCS acquisition

MCS ERROR - LED; indicates that the MCS scaler output was not transferred to memory during the Dwell Time specified

PROGRAM CONTROLS

ADC GAIN - 256 to 8192 channels in binary increments

ADC RANGE - 256 to 8192 channels in binary increments

DIGITAL OFFSET - 0 to 8192 channels in increments of 1 channel

PERFORMANCE

AMPLIFIER

GAIN RANGE - Product of Coarse and Fine Gain Controls; range of X3.2 to X3000

GAIN DRIFT - <±0.0075%/°C of full scale

DC LEVEL DRIFT - <±50μV/°C

INTEGRAL NON-LINEARITY - <±0.05% of full scale

PULSE SHAPING - Gaussian, 3μsec

NOISE - <4μV RMS referred to input at gain >100

RESTORER - Gated

OVERLOAD RECOVERY - To within 2% of full scale output from X1000 overload in 2.5 non-overload pulse widths (<45μsec) at full gain with proper P/Z

SPECTRUM BROADENING - <15% from 2k cps to 50k cps for the 1.33 MeV Co-60 peak at a 9 volt pulse height

COUNT RATE STABILITY - Shift <0.035% from 2k cps to 50k cps for the 1.33 MeV Co-60 peak at a 9 volt pulse height

SCA

INTEGRAL NON-LINEARITY - <±0.25% of full scale

RESOLUTION - <±0.05% of full scale

DRIFT - <±0.05% of full scale/°C.
<±0.01% of full scale/24 hours at constant temperature

PULSE PAIR RESOLUTION - 1μsec minimum

SCA OFFSET FROM ADC WINDOW - <±0.5% of full scale

ADC

INTEGRAL NON-LINEARITY - <±0.025% of full scale over top 99% of range

DIFFERENTIAL NON-LINEARITY - <±1% over top 99% of range

DRIFT

Gain - <±0.01% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature

Zero - <±0.01% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature

COUNT RATE SHIFT - <±0.25% of full scale at rates up to 50kHz

CONVERSION TIME - 2.5 +0.01 (N + X) μsec, where N = Converted Value and X = the amount of Digital Offset. Multiply (N + X) by 2 and 4 for 512 and 256 gain, respectively

CHANNEL PROFILE - On 8192 gain, flat over >80% of width; on other gains flat over >90% of channel width

TIME BASE - Live and True Time stored in channels 0 and 1, respectively. Live Time gated with a 1MHz crystal controlled clock and prescaled to 1 second increments of memory

MCS

PULSE PAIR RESOLUTION - 50 nanosec minimum

COUNT CAPACITY - 2^{20}-1 (2^{16}-1 for dwell times ⩽1.0msec.)

DEAD TIME PER DWELL PERIOD - <250 nanosec

SWEEP MODES - Up/Up or Up/Down, Add or Subtract

SWEEP RANGE - 256 to 16,384 channels in binary increments

DWELL TIME - 10μsec to 9 hours per channel. Coded value stored in Channel 1.

PHYSICAL

Occupies one FEM position in an 860X Processor or 8683A Expansion Chassis

OPTIONS

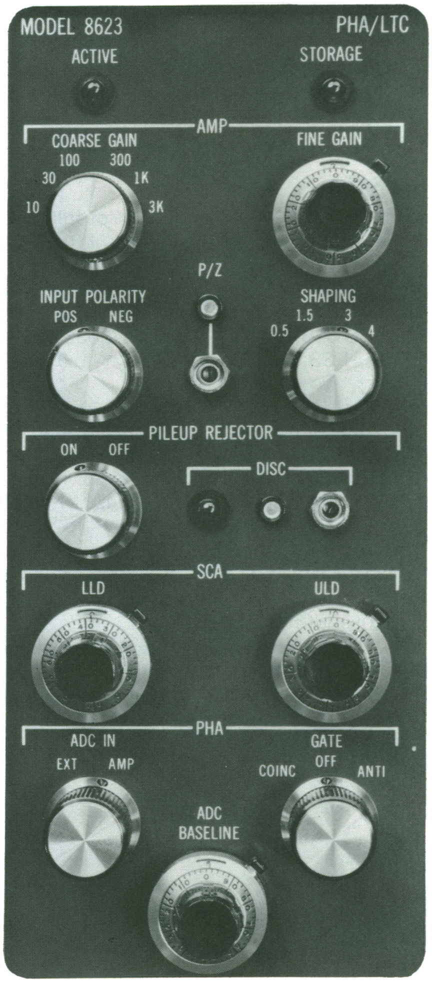
Signal Processing portion only available as 8622A. Occupies the Signal Processing portion of an FEM and utilizes an existing ADC and Collect Interface.

For use with 8200 Digital Stabilizer a wiring option is available. Specify 8625 for 860X and 8626 for 8683A. This will allow stabilization of Gain and/or zero. The amount of change possible is ≈±1%.

Model 8623
PHA/LTC

Features

- True spectroscopy amplifier with gated active baseline restorer
- Switch selectable shaping time constants of 0.5, 1.5, 3, and 4μsec.
- Noise $<3.5\mu$V RMS referred to input at gain >100
- Leading and trailing edge pulse pileup rejection
- Live time correction for pulse pileup deadtime
- 100MHz Wilkinson ADC with 8192 channel conversion gain
- Programmable conversion gain, range, and digital offset
- Direct memory access (DMA) data storage with $<2.5\mu$sec transfer time
- Compatible with Canberra Series 80 MCA and Model 8683A expansion chassis



Description

The Model 8623 PHA/LTC is a plug-in signal processing module for the Canberra Series 80 family of Multichannel Analyzers. The 8623 occupies a single Front End Module (FEM) slot, and may be mounted in either a Series 80 mainframe chassis or the Model 8683A Expansion Chassis.

Functionally, the 8623 provides a high grade spectroscopy amplifier, a Pulse Pileup Rejector/Live Time Corrector, independent SCA, and a 100MHz Wilkinson ADC together with all needed system interfacing. The system interface includes program control of the ADC Conversion Gain, Range, and Offset plus Direct Memory Access (DMA) data storage. Both Live and True Time are provided, with the times being stored in Channels 0 and 1, respectively.

The system interface also provides for PHA mode selection (Add or Subtract), channel overflow interrupts and program controlled data transfers for Digitize and List operation.

The amplifier portion of the 8623 features variable shaping time constants and a gated active baseline restorer, ensuring maximum system resolution. And the Pulse Pileup Rejector/Live Time Corrector essentially eliminates count rate considerations. An ideal combination for Ge(Li) spectroscopy.

The 8623 is one of several signal processing FEM's for the Series 80 MCA. Using the 8683A Expansion Chassis, the Series 80 can be field expanded to a total of four independent FEM's.

Specifications

INPUTS

ADC IN - Positive Unipolar, Bipolar (Pos Leading), or dc Levels; 0 to 10V. Rise Time >250 nsec; Width 1 μsec min to 30 μsec max (longer on request). $Z_{in} \approx 1.2$k ohms, dc Coupled. Rear Panel BNC

GATE IN - Positive Logic Pulse or Level, +2.5 to +8.5V; Width >100 nsec, dc Coupled; Rear Panel BNC

AMP IN - Positive or Negative linear pulses. Amplitude 0 to 12 volts max; 0 to 3.2 volts for a linear output. Rise Time $<$Shaping Time Constant. Decay Time Constant 30 μsec to ∞. $Z_{in} \approx 1$k ohms; Rear Panel BNC

OUTPUTS

SCA OUT - Positive Logic Pulse generated when input falls through the LLD. Width ≈ 0.5 μsec; $Z_{out} \approx 50$ ohms. Rear Panel BNC

FRONT PANEL CONTROLS

AMPLIFIER

COARSE GAIN - Six position rotary switch with factors of X10, X30, X100, X300, X1000, X3000

FINE GAIN - Ten-turn Locking Pot with range of X0.3 to X1

POLE ZERO - 22-turn screwdriver adjustment

INPUT POLARITY - Two position Toggle Switch selects Positive or Negative Input.

SHAPING - Four position rotary switch; provides 0.5, 1.5, 3, or 4μsec. shaping time constants.

PILEUP REJECTOR - Two position rotary switch to enable or disable the PUR/LTC.

DISC - 22-turn screwdriver adjustment for PUR discriminator level

SCA

LLD - Ten-turn Locking Pot; 0 - 110% of input

ULD - Ten-turn Locking Pot; 0 - 110% of input

ADC

ADC IN - Two position Toggle Switch to select the internal or an external amplifier as the ADC and SCA input.

ADC BASELINE - Ten-turn Locking Pot; ±6% of full scale.

GATE - Three position Rotary Switch. Selects Coincidence or Anticoincidence Gating; Off Position disables gate. Internal jumpers for Early or Late Coincidence and Sample Voltage Analysis. Factory set for Late Coincidence

PROGRAM CONTROLS

ADC GAIN - 256 to 8291 channels in binary increments

ADC RANGE - 256 to 8192 channels in binary increments

DIGITAL OFFSET - 0 to 8192 channels in increments of 1 channel.

INDICATORS

ACTIVE - LED; indicates the 8623 has been enabled to take data

STORAGE - LED; indicates that a conversion has been stored

DISC - LED; indicates triggering of PUR discriminator

PERFORMANCE

AMPLIFIER

GAIN RANGE - Product of Coarse and Fine Gain Controls; range of X3.2 to X3000

GAIN DRIFT - <±0.0075% of full scale/°C

DC LEVEL DRIFT - <±50μV/°C of full scale

INTEGRAL NON-LINEARITY - <±0.05% of full scale

PULSE SHAPING - Gaussian, with time constants of 0.5, 1.5, 3, and 4μsec

NOISE - <4μV RMS referred to input at gain >100 and 3μsec shaping

RESTORER - Gated

OVERLOAD RECOVERY - To within 2% of full scale output from X1000 overload in 2.5 non-overload pulse widths (<45μsec) at full gain with proper P/Z and 3μsec shaping

SPECTRUM BROADENING - <15% from 2k cps to 50k cps for the 1.33 MeV Co-60 peak at a 9 volt pulse height, (3 μsec shaping)

COUNT RATE STABILITY - Shift <0.035% from 2k cps to 50k cps for the 1.33 MeV Co-60 peak at a 9 volt pulse height (3 μsec shaping)

PILEUP REJECTOR/LIVE TIME CORRECTOR

INPUT - Internally connected to the Amp and ADC Linear Gate.

OUTPUT - Internally connected to the Live Time Clock

PULSE PAIR RESOLUTION - <500 nanosec

MINIMUM DETECTABLE ENERGY - <1% of amplifier full scale output

SCA

INTEGRAL NON-LINEARITY - <±0.25% of full scale.

RESOLUTION - <±0.05% of full scale.

DRIFT - <±0.05% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature.

PULSE PAIR RESOLUTION - 1μsec minimum.

OFFSET FROM ADC WINDOW - <±0.5% of full scale

ADC

INTEGRAL NON-LINEARITY - <±0.025% of full scale over top 99% of range

DIFFERENTIAL NON-LINEARITY - <±1% over top 99% of range

DRIFT

Gain - <±0.01% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature

Zero - <±0.01% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature

COUNT RATE SHIFT - <±0.25% of full scale at rates up to 50kHz

CONVERSION TIME - 2.5 +0.01 (N + X) μsec, where N = Converted Value and X = the amount of Digital Offset. Multiply (N + X) by 2 and 4 for 512 and 256 gain, respectively

CHANNEL PROFILE - On 8192 gain, flat over >80% of width; on other gains flat over >90% of channel width

TIME BASE - Live and True Time stored in channels 0 and 1, respectively. Live Time gated with a 1MHz crystal controlled clock and prescaled to 1 second increments of memory

PHYSICAL

Occupies one FEM position in an 860X Processor or 8683A Expansion Chassis

OPTIONS

Signal Processing portion only available as 8623A. Occupies the Signal Processing portion of an FEM and utilizes an existing ADC and Collect Interface

For use with 8200 Digital Stabilizer a wiring option is available. Specify 8625 for 860X and 8626 for 8683A. This will allow stabilization of the Gain and/or zero by changing the ADC gain and/or zero. The amount of change possible is ≈±1%.

Model 8624
ADC/Gated MR

Features

- Provides 1, 2, or 4 input PHA
- Independent linear gate on each input eliminates crosstalk and peak distortion
- Independent live and true time for each input
- 100MHz Wilkinson ADC with 8192 channel conversion gain
- Programmable conversion gain, range, and digital offset
- Digital offset selectable in one channel increments from 0 to 8191 channels
- Compatible with Canberra Series 80 MCA and Model 8683A Expansion Chassis

Description

The Model 8624 ADC/MR is a plug-in signal processing module for the Canberra Series 80 family of Multichannel Analyzers. The 8624 occupies a single Front End Module (FEM) slot, and may be mounted either in a Series 80 mainframe chassis or the Model 8683A Expansion Chassis.

Functionally, the 8624 provides a four input Mixer/Router, independent SCA, 100MHz ADC, and all necessary system interfacing. In addition to Direct Memory Access (DMA) data storage, the interface also provides program control of the ADC Conversion Gain, Range, and Digital Offset. Conversion Gain and Range are independently selectable from 256 to 8192 channels in binary increments. Digital Offset is selectable in one channel increments.

The system interface also provides for PHA mode selection (Add or Subtract), channel overflow interrupts and program controlled data transfers for Digitize and List operation.

Each input to the 8624 Mixer/Router has its own linear gate, eliminating crosstalk and peak distortion. And separate time channels - both Live and True - are maintained for each of the four inputs. A direct ADC input is also provided for experiments which do not require the Mixer/Router capability.

The 8624 is one of several signal processing FEM's available for the Series 80 MCA. Using the 8683A Expansion Chassis, a Series 80 system can be field expanded to a total of four FEM's.

Specifications

INPUTS

ADC IN - Positive Unipolar, Bipolar (Pos. Leading), or dc Levels; 0 to +10V. Rise Time $>$250 nsec; Width 1 μsec min to 30 μsec max (longer on request). $Z_{in} \approx$1.2k ohms, dc coupled. Front and Rear Panel BNCs. Front Panel Test Point

MIXER ROUTER IN - Maximum of four inputs, dc coupled. Accepts positive unipolar or bipolar pulses, or dc levels. Amplitude 0 to 10V; Rise Time $>$250 nanosec; Width 1 to 30 μsec; Impedance $\approx$1k ohms. Front Panel BNCs and Test Points

GATE IN - Separate gates for ADC and each M/R input. Positive Logic Pulses or Levels; 2.5 to 8 volts; Width $>$100 nanosec; dc coupled. Front Panel BNCs and Test Points. Rear Panel BNC for ADC Gate

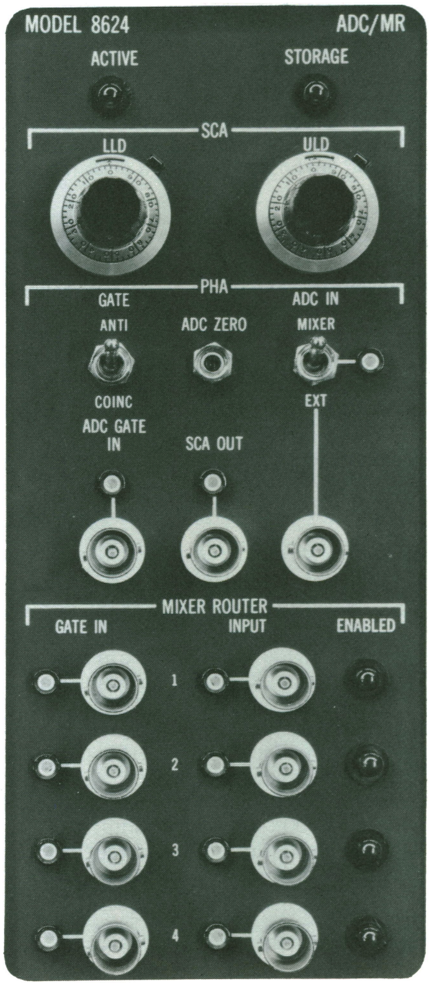
OUTPUTS

SCA OUT - Positive Logic Pulse generated when ADC input falls through the LLD. Width $\approx$0.5μsec; $Z_{out} \approx$50 ohms. Front and Rear Panel BNCs, Front Panel Test Point

FRONT PANEL CONTROLS

LLD - Ten-turn Locking Pot; 0 - 110% of input

ULD - Ten-turn Locking Pot; 0 - 110% of input



GATE - Two position toggle switch. Selects Coincidence or Anticoincidence operation for the Gate inputs to the ADC and Mixer/Router. The ADC has jumpers to allow Early or Late Coincidence and Analog Sampling. The Mixer/Router section only has jumper provision for Early Coincidence or Anticoincidence and Analog Sampling. Unit is factory set to:

ADC - Late Coincidence
Early Anticoincidence
M/R - Early Coincidence
Early Anticoincidence

With no input connected, the ADC and M/R are enabled in either position of the switch.

ADC ZERO - 22-turn screwdriver adjustment; ±6% of full scale

ADC IN - Two position Toggle Switch to select either the internal M/R or an external amplifier as the input to the ADC and SCA.

PROGRAM CONTROLS

ADC GAIN - 256 to 8192 channels in binary increments.

ADC RANGE - 256 to 8192 channels in binary increments.

DIGITAL OFFSET - 0 to 8192 channels in increments of 1 channel.

INDICATORS

ACTIVE - LED; indicates the 8624 has been enabled to take data.

STORAGE - LED; indicates that a conversion has been stored

ENABLE - LED; one for each M/R input. Indicates that the associated input has been enabled for data acquisition.

Specifications(continued)

PERFORMANCE

MIXER/ROUTER

GAIN - Unity ±2%

DYNAMIC RANGE - 0 to +10V

INTEGRAL NON-LINEARITY - <±0.05% of full scale over top 99% of range.

GAIN DRIFT - <±0.02% of full scale/°C

ZERO DRIFT - <±100μV/°C

CHANNEL ISOLATION - >60db with 100KHz random source and 0.5μs shaped input pulse.

TIME BASE - Independent Live and True Times are stored in channels zero and one, respectively, for each input. Live Time is derived from a 1MHz crystal clock and is corrected for each input individually; the correction includes ADC deadtime, M/R processing time, and M/R deadtime due to an input pulse being lost because the M/R and ADC are busy processing a pulse from one of the other input channels.

M/R ENABLE - Each input can be individually enabled or disabled (started or stopped) via the SERIES 80 Processor

SCA

INTEGRAL NON-LINEARITY - <±0.25% of full scale

RESOLUTION - <±0.05% of full scale

DRIFT - <±0.05% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature

PULSE PAIR RESOLUTION - 1μsec minimum

OFFSET FROM ADC WINDOW - <±0.5% of full scale

ADC

INTEGRAL NON-LINEARITY - <±0.025% of full scale over top 99% of range

DIFFERENTIAL NON-LINEARITY - <±1% over top 99% of range

DRIFT

Gain - <±0.01% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature

Zero - <±0.01% of full scale/°C
<±0.01% of full scale/24 hours at constant temperature

COUNT RATE SHIFT - <±0.025% of full scale at rates up to 50kHz

CONVERSION TIME - 2.5 +0.01 (N + X)μsec, where N = Converted Value and X = the amount of Digital Offset. Multiply (N + X) by 2 and 4 for 512 and 256 gain, respectively

CHANNEL PROFILE - On 8192 gain, flat over >80% of width; on other gains flat over >90% of channel width

TIME BASE - Live and True Time stored in channels 0 and 1, respectively. Live Time gated with a 1MHz crystal controlled clock and prescaled to 1 second increments of memory

PHYSICAL

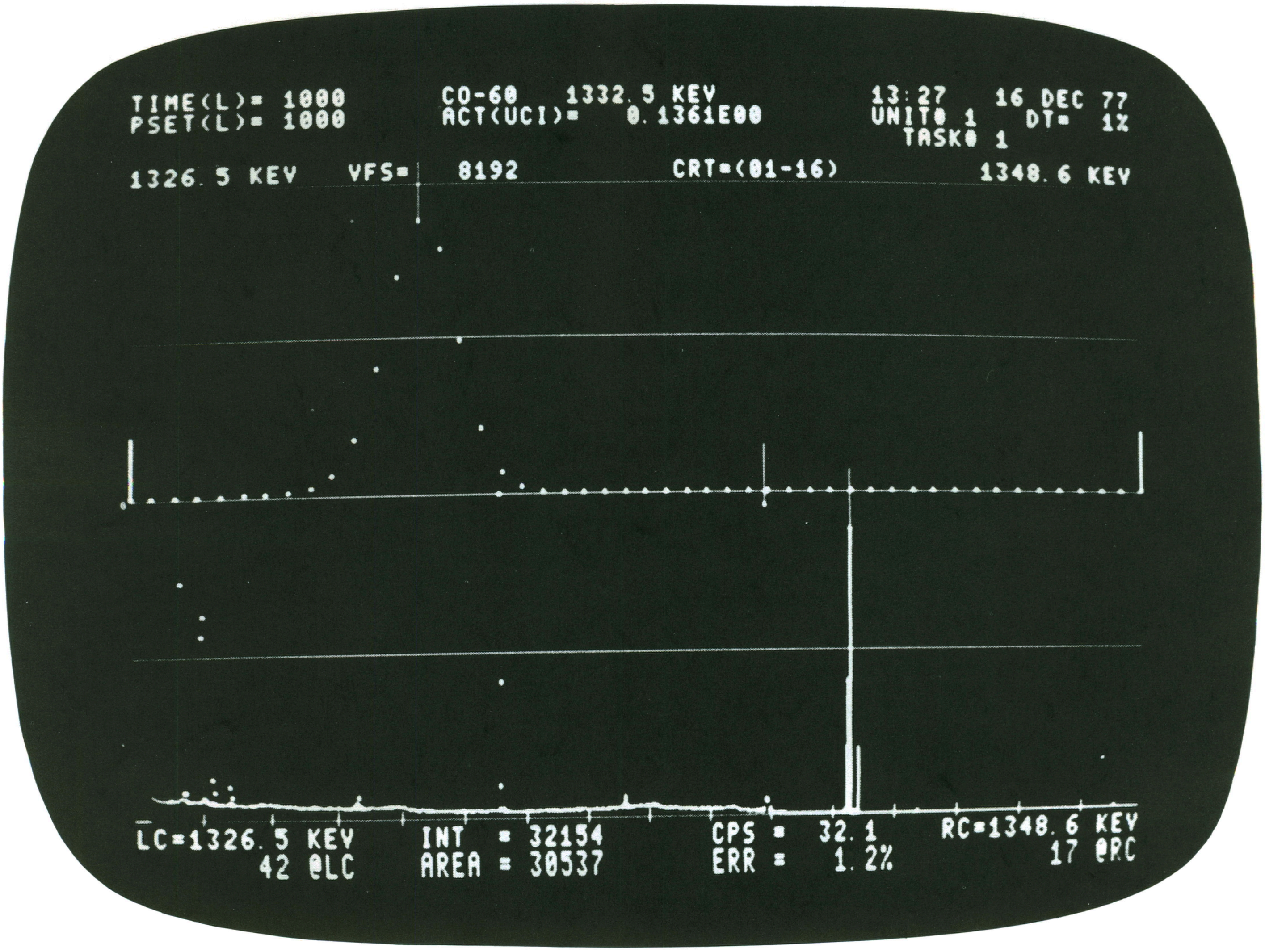
Occupies one FEM position in an 860X Processor or 8683A Expansion Chassis

OPTIONS

Signal Processing portion only available as 8624A. Occupies the Signal Processing portion of an FEM and utilizes an existing ADC and Collect Interface

For use with 8200 Digital Stabilizer a wiring option is available. Specify 8625 for 860X or 8626 for 8683A. This will allow stabilization of Gain and/or zero by changing the ADC Gain and/or zero. The amount of change possible is ≈±1%. Consult factory is one of the router channels is to be stabilized.

Series 80 MCA Analysis Options



```
TIME(L)= 1000        CO-60    1332.5 KEV         13:27   16 DEC 77
PSET(L)= 1000        ACT(UCI)=    0.1361E00      UNIT# 1   DT=  1%
                                                   TASK# 1
1326.5 KEV    VFS=   8192         CRT=(01-16)         1348.6 KEV

LC=1326.5 KEV      INT  = 32154       CPS =  32.1    RC=1348.6 KEV
       42 @LC      AREA = 30537       ERR =  1.2%          17 @RC
```

Figure 1
Sample ISO QUAN Display.

Features

MODEL 8641 PEAK ANALYSIS

- 1st or 2nd Order energy calibration
- Peak net area with multipoint background averaging
- Counting statistics
- Automatic peak search, centroid location, and FWHM computation

MODEL 8642 DATA MANIPULATION

- 3 or 5 point spectrum smoothing
- Spectrum normalization
- Fractional spectrum stripping
- Ratio computation

MODEL 8643 ISO ID

- Automatic isotope identification
- User library generation
- Library editing and I/O

MODEL 8644 ISO QUAN

- Detector efficiency calibration
- Automatic quantitative isotopic analysis with decay correction

MODEL 8645 LEARN/EXECUTE

- 7 sequences with 64 steps each
- Sample changer controller

Description

MODEL 8641 PEAK ANALYSIS

Included in the Model 8641 Peak Analysis Option are those functions required to locate and analyze the peaks within a spectrum. The specific functions provided and their operation are as follows:

Digital Energy Calibration - Provides a convenient means of converting MCA channel numbers to the equivalent engineering units. During the calibration process the user may select a unit designator of EV, KEV, MEV, USEC (microseconds), MSEC, or SEC. The calibration itself is performed via a least squares fit to either a first or second order expression as specified by the user. The resultant equation [Units = A x (Chan #) + B, or Units = A x (Chan #)^2 + B x (Chan #) + C] is then used to convert the CRT display — plus any associated printout — to engineering units rather than channel numbers. Up to twenty (20) different calibration equations — each with its own engineering units and its own region of memory — can be in effect at one time.

Peak Net Area - Computes and displays the net area above background and the associated counting statistics for the data region between the cursors. Background is determined via a straight line between end point values, which are determined by averaging the first N and last N points of the region between the cursors. The user may establish the desired value for N (from 1 to 255) as well as the confidence level to be used for computing the counting statistics (.01 σ to 3.27 σ). During readout intensified ROIs, rather than cursor position, determine the memory regions for which the net area will be required.

Peak Search - The PEAK function provides a means of automatically locating peaks within a spectrum. Depending upon the state of the INTENSIFY indicator at the time that PEAK is initiated it will either. .

a. Locate all statistically significant peaks within a spectrum and place an intensified ROI about each, or

b. Locate the centroid of a peak between the cursors and. . .

1. Place markers at the left limit, right limit, and centroid,
2. Display the centroid channel number or energy, and
3. Display the peak FWHM.

Peak location is performed via a first difference method. For a potential peak to be considered valid it must pass minimum width criteria plus a statistical significance test. These parameters may be set by the user. In addition, all potential multiplets (peaks exceeding the maximum width) are flagged to indicate that further analysis is required.

MODEL 8642 DATA MANIPULATION

The Model 8642 Data Manipulation option provides a set of functions for mathematically manipulating spectral data, as follows:

Ratio Computation - The function RATIO provides a means of quickly determining the mathematical relationship between two elements of spectral data. These elements may be. . .

a. The contents of any two channels, or

b. The integral of any two regions of memory, or

c. The net area of any two regions of memory.

During operation, the ratio value is computed (within a range of 0.01 to 327.67), displayed on the CRT, and stored in scratchpad memory for later use by STRIP.

Fractional Spectrum Stripping - The STRIP function provides traditional fractional stripping in the form of $Y' = Y - R \times Z$. Y and Z are two spectra stored in the Series 80 data memory, and R is a signed value that is either. . .

a. The last computed RATIO, or

b. An operator entered value, as the user wishes.

Spectrum Normalization - NORMALZ provides spectrum normalization in the form of $Y' = M \times Y + K$. The multiplicative operator (M) has a range of -327.67 to +327.67; the additive operator (K) has a range of $\pm 10^9 - 1$. Both M and K are established by the operator.

Spectrum Smoothing - The function SMOOTH provides both three (3) and five (5) point spectrum smoothing, as follows:

a. 3 Point: $Y_i = \dfrac{Y_{i-1} + 2Y_i + Y_{i+1}}{4}$

b. 5 Point: $Y_i = \dfrac{Y_{i-2} + 4Y_{i-1} + 6Y_i + 4Y_{i+1} + Y_{i+2}}{16}$

The operator specifies the type of smoothing desired.

MODEL 8643 ISO ID

Included in the Model 8643 ISO ID option are a Standard Isotope Library which resides in ROM (Read Only Memory - see Table 1), a User-Definable Library which resides in RAM (Random Access Memory), and those functions required for library I/O and automatic isotope identification. Model 8641 Peak Analysis is a prerequisite of Model 8643.

Library Input - Used to load a User-Defined Library into the Series 80. The maximum library size is approximately 50 isotopes (or elements) with 150 peak energies. When the input device is the terminal keyboard (TTY, DECwriter, etc.) an editing routine allows the user to easily type in a custom library. In addition, libraries may be read in from a wide variety of devices such as floppy disk, magnetic tape, cassette tape, and paper tape. Since each library includes its own calibration units, custom libraries oriented toward X-ray, gamma, and alpha spectroscopy can be easily established.

Library Output - The function LIB OUT provides a means of listing the libraries and for saving them for later loading (via LIB IN) and analysis. The operator may select any suitable readout device, including terminals, floppy disk, magnetic tape, cassette tape, etc., as part of the LIB OUT dialogue.

Virtual Libraries - With the floppy disk (8662) option, 8 disk-resident libraries can be defined, and used for analysis without loading into the user Library.

	NAME	t 1/2	ENERGY (keV)	YIELD (%)
1	NA - 22	2.60 Y	511.0	0
			1274.5	100
2	NA - 24	15.00 H	1368.5	100
			2754.1	100
3	K - 40	0.126E9 Y	1460.8	11
4	CR - 51	27.70 D	320.1	10
5	MN - 54	312.50 D	834.8	100
6	CO - 56	77.30 D	511.0	0
			846.8	100
			1037.8	14
			1238.2	68
			1771.2	16
			2598.4	17
7	MN - 56	2.58 H	846.8	99
			1811.2	30
			2112.6	16
8	CO - 57	270.89 D	122.1	85
			136.5	11
9	CO - 58	70.80 D	511.0	0
			810.8	99
10	FE - 59	44.60 D	1099.2	57
			1291.6	43
11	CO - 60	5.27 Y	1173.2	100
			1332.5	100
12	ZN - 65	244.09 D	1115.5	49
13	KR - 85M	4.50 H	151.0	75
			304.9	14
14	SR - 85	64.90 D	514.0	100
15	KR - 87	1.27 H	402.6	47
16	KR - 88	2.80 H	196.3	29
			834.8	14
			1529.8	12
			2195.8	14
			2392.1	38
17	Y - 88	108.00 D	898.0	91
			1836.0	100
18	KR - 89	3.17 M	220.9	20
			585.8	17
19	RB - 89	15.20 M	657.7	10
			947.7	9
			1031.9	59
			1248.1	43
			2196.0	14
			2570.0	10
20	SR - 91	9.50 H	652.8	12
			749.8	24
			1024.3	33
21	Y - 91M	49.70 M	555.6	58
22	NB - 95	35.20 D	765.8	100
23	ZR - 95	64.00 D	724.2	43
			756.7	55
24	RU - 103	39.40 D	497.1	86
25	CD - 109	453.00 D	88.0	4
26	AG - 110M	252.20 D	657.7	93
			706.7	16
			884.7	71
			937.4	34
			1384.3	24
			1505.0	13
27	SN - 113	115.00 D	392.0	100
28	SB - 124	60.20 D	602.7	98
			722.8	11
			1691.0	49
29	SB - 126	12.40 D	414.8	81
			695.1	100
			720.5	56
30	I - 131	193.20 H	80.2	2
			284.3	6
			364.5	80
			637.0	7
			722.9	2
31	XE - 131M	11.90 D	163.9	2
32	I - 132	2.30 H	505.9	5
			522.7	16
			630.2	14
			667.7	99
			772.6	76
			954.6	17
33	BA - 133	7.20 Y	80.8	36
			276.4	7
			302.8	18
			356.0	62
			383.8	9
34	I - 133	20.80 H	529.9	87
			875.4	4
35	XE - 133	5.30 D	81.0	37
36	XE - 133M	2.19 D	233.2	10
37	CS - 134	2.05 Y	569.3	15
			604.7	98
			795.8	85
38	I - 134	52.60 M	595.4	11
			847.0	95
			884.1	65
			1072.6	15
			1136.2	10
39	I - 135	6.60 H	546.6	7
			1038.8	8
			1131.5	23
			1260.4	29
			1457.6	9
			1678.0	10
40	XE - 135	54.50 M	249.8	92
			607.8	3
41	XE - 135M	15.70 M	526.6	81
42	CS - 136	13.10 D	340.6	47
			818.4	100
			1048.1	80
43	CS - 137	30.20 Y	661.6	85
44	CS - 138	32.20 M	462.8	27
			546.9	11
			1009.8	30
			1435.9	76
			2218.0	15
45	XE - 138	14.20 M	258.3	32
			396.4	6
			434.5	20
			1768.3	17
46	BA - 139	82.70 M	165.9	22
47	CE - 139	140.00 D	165.9	80
48	BA - 140	12.80 D	537.3	24
49	BA - 141	18.30 M	190.2	46
			304.2	25
50	CE - 141	32.50 D	145.4	48
51	CE - 144	284.30 D	133.5	11
52	TA - 182	115.10 D	68.0	42
			100.0	14
			1121.2	34
			1189.0	16
			1221.4	27
			1231.0	12
53	W - 187	23.90 H	134.2	10
			479.5	27
			551.6	6
			618.2	7
			685.8	32
			772.9	4
54	HG - 203	46.90 D	279.0	81
55	BI - 207	30.00 Y	569.6	98
			1063.7	77
			1770.2	7
56	BI - 214	19.90 M	609.3	46
			1120.3	15
			1764.5	16
57	PB - 214	26.80 M	295.2	19
			351.9	37
58	U - 235	2.6E11 D	185.7	56
59	NP - 237	2.1E6 Y	29.4	10
			86.5	13
60	PU - 238	87.80 Y	99.0	0
			150.0	0
61	NP - 239	56.40 H	106.1	23
			228.2	11
			277.6	14
			315.9	2
62	PU - 239	24.4E3 Y	52.0	0
			129.3	0
			375.0	0
			413.7	0
63	AM - 241	432.99 Y	59.5	36

Table 1
Model 8643 Standard Library

Isotope Library Scanning - ISO SCAN provides the user with a rapid means of scanning the contents of an Isotope Library. Using SCAN the operator can sequentially display, in ascending or descending order, each entry in either the Standard or User-Defined Library. The name of each entry is displayed on the CRT together with blinking markers at the location of each peak associated with the entry.

Automatic Isotopic Analysis - Two modes of automatic Isotope Identification are provided by the ISO ID function. When used in a non-readout situation, enabling ISO ID causes. . .

a. The location of the Left cursor (or centroid of the peak between the cursors, if PEAK is on) is read, converted to energy using the calibration equation, and stored as the target energy.

b. The specified library is searched until a peak energy equal to target ± W is found (W is an operator-specified energy window).

c. The isotope name associated with that peak is displayed on the CRT, along with markers at all other peaks listed for this entry.

Should a visual examination indicate an incorrect choice, pushing ISO ID again will continue the search.

During readout, a similar type of search is made using the peak centroid of each intensified ROI as the target energy; all matches are reported.

MODEL 8644 ISO QUAN

Model 8644 provides those functions required for detector efficiency calibration and quantitative isotopic analysis. Models 8641 and 8643 are prerequisites.

Efficiency Calibration - The EFF CAL function provides a convenient means of performing detector Efficiency Calibration. Operating upon operator-selected peaks within a spectrum acquired from a calibrated reference source, EFF CAL computes the absolute detector efficiency (including any needed source age correction) for each peak and enters the value into a 32 entry Efficiency versus Energy Table.

Efficiency Table Output - Once an Efficiency Table has been generated it may be stored for later use by the function EFF OUT. The contents of the table may be read out to any suitable device including TTYs, floppy disk, magnetic tape, cassette tape, etc.

Efficiency Table Input - Previously saved tables are loaded back into the Series 80 via EFF IN. Manual table entry may be performed as a subset of the EFF CAL function.

Quantitative Isotopic Analysis - ISO QUAN performs the actual quantitative analysis. The technique used to perform the analysis is as follows:

a. Look up the target energy in the ISO ID Library to determine the isotope being analyzed plus the half-life and gamma yield for the target peak.

b. Look up the target energy in the Efficiency Table, using linear interpolation as needed, to determine the proper efficiency value.

c. Compute the current activity, in μCuries, via. . .

$$\mu\text{Ci} = \frac{\text{Net Area} \times 2.7 \times 10^{-5}}{\text{Live Time} \times \text{Efficiency} \times \text{Yield}}$$

d. Perform decay correction, via. . .

$$\mu\text{Ci} @ t_0 = \mu\text{Ci} \times \mathbf{e}^{\frac{.693 \times \text{Decay Time}}{\text{Half-Life}}}$$

Depending upon the exact system configuration and operating mode, the above procedure can be invoked in several ways. In addition system configuration also effects the manner in which Efficiency Tables are handled.

a. **Systems Without Floppy Disk** - 4 Tables are provided. These may be loaded via EFF CAL or EFF IN. Any task – Manual, Single Cycle, Recycle, or Learn/Execute – performing an ISO QUAN may access any of these tables.

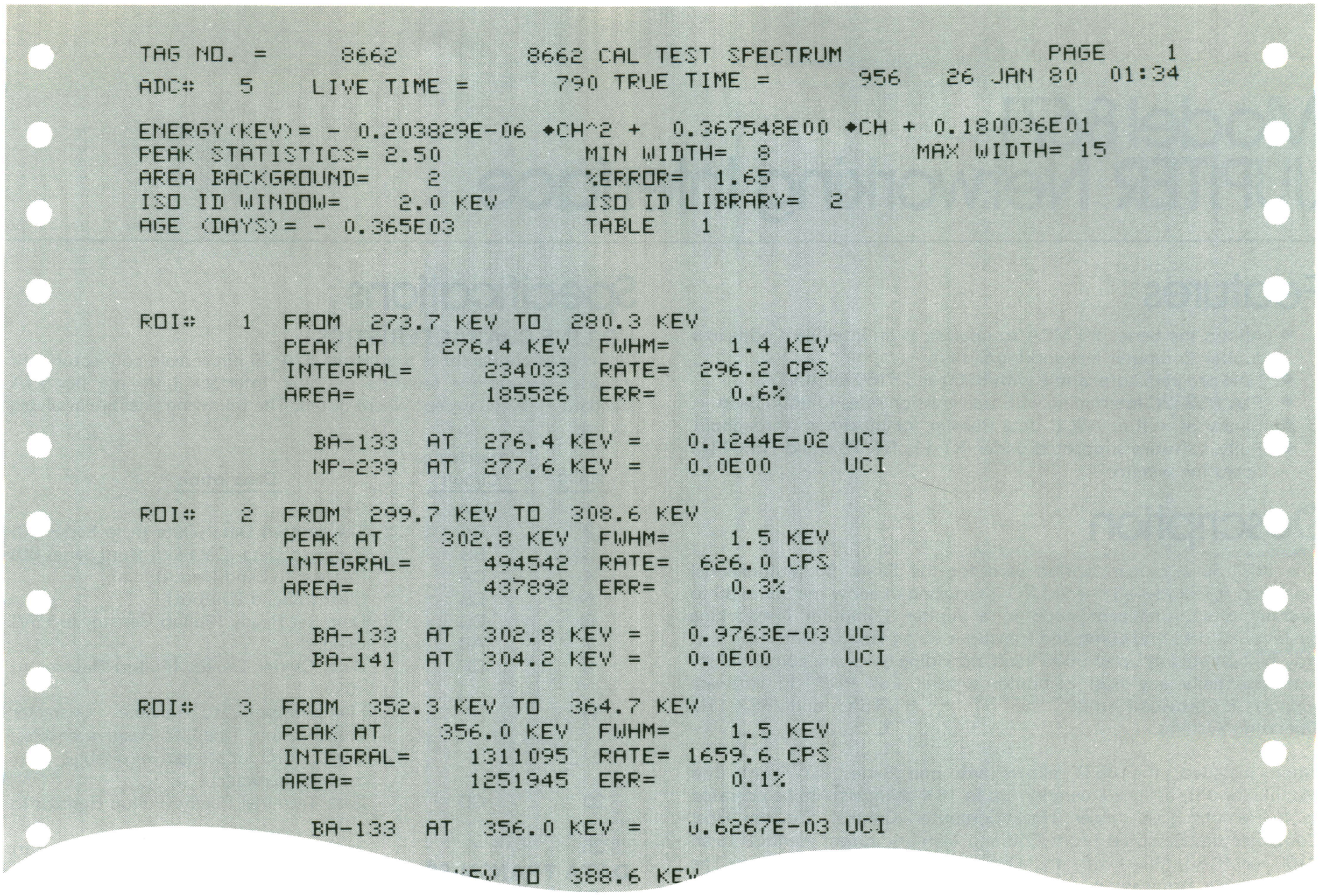
b. **Systems With Floppy Disk** - When a system is equipped with a floppy disk, and Efficiency Tables are stored on the disk, a Virtual Memory mechanism can be invoked. This allows each of up to eight (8) independent tasks to have its own Efficiency Table, with all needed paging and swapping performed automatically.

c. **ISO QUAN With No Readout** - When performing visual quantitative analysis (CRT display only of results; see Figure 1) the analysis is done using . . .

1. The isotope found by a previous ID.
2. The current AREA, as defined by the cursors.
3. The decay time specified for this unit in ENTER FACTOR.

Efficiency Table selection and analysis are as described above.

d. **ISO QUAN With Readout** - When used in conjunction with a readout operation, ISO QUAN uses as its target energy the centroid of the peaks contained within intensified ROIs. Efficiency Table selection and analysis described above. (See Figure 2 for a sample report.)



```
TAG NO. =      8662         8662 CAL TEST SPECTRUM                PAGE    1
ADC#    5    LIVE TIME =      790 TRUE TIME =       956   26 JAN 80   01:34

ENERGY(KEV)= - 0.203829E-06 *CH^2 +  0.367548E00 *CH + 0.180036E01
PEAK STATISTICS= 2.50           MIN WIDTH=  8          MAX WIDTH= 15
AREA BACKGROUND=    2           %ERROR=  1.65
ISO ID WINDOW=     2.0 KEV      ISO ID LIBRARY=  2
AGE (DAYS)= - 0.365E03          TABLE   1


ROI#    1  FROM  273.7 KEV TO  280.3 KEV
           PEAK AT     276.4 KEV  FWHM=     1.4 KEV
           INTEGRAL=      234033  RATE=  296.2 CPS
           AREA=          185526  ERR=      0.6%

             BA-133  AT  276.4 KEV =   0.1244E-02 UCI
             NP-239  AT  277.6 KEV =   0.0E00     UCI

ROI#    2  FROM  299.7 KEV TO  308.6 KEV
           PEAK AT     302.8 KEV  FWHM=     1.5 KEV
           INTEGRAL=      494542  RATE=  626.0 CPS
           AREA=          437892  ERR=      0.3%

             BA-133  AT  302.8 KEV =   0.9763E-03 UCI
             BA-141  AT  304.2 KEV =   0.0E00     UCI

ROI#    3  FROM  352.3 KEV TO  364.7 KEV
           PEAK AT     356.0 KEV  FWHM=     1.5 KEV
           INTEGRAL=     1311095  RATE= 1659.6 CPS
           AREA=         1251945  ERR=      0.1%

             BA-133  AT  356.0 KEV =   0.6267E-03 UCI

                    EV TO  388.6 KE
```

Figure 2
Sample ISO QUAN Report

MODEL 8645 LEARN/EXECUTE

Model 8645 provides a comprehensive program development and testing facility for use in preparing automatic control and analysis programs based upon sequences of console functions. The Series 80 Multi-Tasking Operating System allows up to seven (7) separate program sequences of 64 bytes each to be resident and in operation at the same time. Sequence chaining permits very long (>64 bytes) sequences to be easily entered and executed. In addition, the 8645 provides a TTL-compatible sample changer controller with the following signals:

OUTPUT: Advance Changer; TTL pulse with Jumper selection of +5V = Change or 0V = Change; Pulse width RC controlled. Factory set to 200 ms.

INPUT: Changer Ready; TTL logic level; +5V True; Must go False prior to the end of the Advance output.

The following console functions are implemented by Model 8645.

LEARN: Provides a means of entering program sequences into the Series 80. Includes provisions for loading previously defined programs from an I/O device (floppy disk, magentic tape, cassette tape, paper tape, etc.) as well as operator entry of programs from the operator's console.

STEP: Provides a program editing, and readout facility. The program sequence editor includes provisions of deleting, changing, or entering new program steps. Readout may be to any of a wide choice of devices (floppy disk, magnetic tape, cassette tape, paper tape, etc.).

EXECUTE: Activates previously defined or loaded program sequences. During the execution of a sequence all Series 80 performance features — including simultaneous Acquisition and I/O — can be utilized. In addition, the operating system provides device queuing and conflict resolution to allow several tasks access to the same peripheral on a first come — first served basis.

PAUSE: The PAUSE function has two different modes of operation.

a. As a direct console function. Activation of PAUSE generates the Advance Changer pulse from the sample changer controller.

b. As a step in a program sequence. . .

1. Generates the Advance Changer pulse, as above.
2. Causes the sequence to wait until the Changer Ready signal is received.

PHYSICAL

All of the above analysis options are mounted on the Series 80 MP ROM Card and are powered from the Series 80 power supply. All can easily be field installed.

Model 8671
JUPITER Networking Interface

Features

- Allows the Series 80 MCA to operate as an intelligent node in a Jupiter Computer Networking System
- Host program compatible with 8100 and 8180 QUANTA
- EIA RS232C interfacing with transmission rates to 9600 baud
- Binary as well as ASCII data transfer for maximum throughput
- Fully software supported under RT-11, RT/TSX and RSX-11M operating systems

Description

The 8671 is a plug-in option card for the Series 80 Multichannel Analyzer. It includes all needed I/O interfacing to allow the Series 80 to operate as an intelligent node in a Jupiter Computer Networking System. All data and command transfer is via an RS232C interface that may be operated at up to 9600 baud, providing hardware compatibility with essentially any host computer system. Full PDP®-11 software support is provided under the RT-11, RT/TSX, and RSX-11M Operating Systems.

When installed, the 8671 allows any one Series 80 Front End Module—and its assigned memory (up to 16K channels)—to be operated as a Remote Task under Host Computer Control. To the Host Computer the Remoted Front End and Memory appear identical to an 8100 or 8180 MCA with the Option 14 QUANTA interface. The Multi-tasking firmware in the Series 80 allows this Remote Task to proceed concurrently with other operator-initiated tasks on the Series 80 MCA.

In addition to providing all 8100/8180 QUANTA functions, the 8671 also includes commands for binary data transfer, significantly reducing the time required for data transfer.

Specifications

I/O LINE CHARACTERISTICS

The chassis connector is a standard EIA 25 pin female connector with threaded inserts for securing a cable. Interface lines are per EIA standard RS232C except where noted. The following lines are available for use:

Pin #	Interchange Circuit	Description
1	AA	Ground
2	BA	Transmitted Data (Data In to Series 80)
3	BB	Received Data (Data Out from Series 80)
4	CA	Request to Send (Input)
5	CB	Clear to Send (Output)
6	CC	Data Set Ready (Pullup Resistor to +5V)
7	AB	Ground
8	CF	Data Carrier Detect (Pullup Resister to +5V)
11	–	Flag (Input to enable Character Transmission; Open or Positive enables; Level of O or Negative disables after current character)
20	CD	Data Terminal Ready (Pullup Resistor to +5V)
25	–	Busy (TTL Output; Polarity Jumper Set)

DATA TRANSMISSION

BAUD RATE - 300, 600, 1200, 2400, 4800, or 9600 via jumper selection.

PARITY - Even.

FORMAT - 1 Start Bit, 8 Data Bits, 1 Parity Bit, 1 Stop Bit.

CONTROLS

The 8671 interface is enabled by assigning an ADC to REMOTE operation via FUNCTION SELECT, ADC on the Series 80 console.

PHYSICAL

Occupies one I/O slot in a Series 80 Processor.

Models 8673/8673C/8673V Communications Interfaces

Features

- Interfaces Series-80 MCA to PDP-11
- 57.6K baud serial transmission
- EIA RS-422 signal levels
- Binary and ASCII data transfer
- Learn/Execute tasks can be downloaded
- RT-11 and RSX-11M software support available

Description

The following models

- 8673 Jupiter Computer Interface
- 8673C UNIBUS Interface for Jupiter
- 8673V Q-BUS Interface for Jupiter

are a family of Canberra high speed EIA RS-422 communications interfaces. They enable a Canberra Series 80 multichannel analyzer to be interfaced to any Digital Equipment Corporation PDP-11® computer to comprise a Canberra Jupiter nuclear analysis computer system. The 8673 Jupiter Computer Interface is a plug-in option card for the Series-80 MCA. The 8673C UNIBUS Interface plugs into any DEC® PDP-11 computer with a UNIBUS (PDP-11/04, -11/34A, -11/60, -11/70, and older models). The Q-BUS (LSI-11) PDP-11 models (PDP-11/03 and -11/23) require the 8673V Q-BUS Interface. The combination of 8673 and 8673C (or 8673V) includes all necessary control and I/O signals to allow the Series-80 MCA to operate as an intelligent "node" in a Jupiter Computer System.

All data and command transfers are via EIA RS-422 signals that may be transmitted at rates up to 57.6k baud. Data can be transferred in either binary or ASCII form.

When installed, the 8673 allows up to four ADC's in a Series-80 MCA to be operated independently as remote tasks under control of the host PDP-11 computer. The multitasking firmware in the Series-80 MCA allows these remote tasks to proceed concurrently with other operator-initiated tasks.

To set up communications between a Series-80 MCA (with 8673) and a PDP-11 computer (with 8673C or 8673V), Canberra has developed a detailed communications protocol. This protocol defines both the hardware functions of the communications lines (e.g. using certain signals as "handshake" lines) as well as the encoding and decoding format of software commands. The software commands can take one of two forms - either as a Learn/Execute Mode Command or as an Immediate Mode Command. The learn/execute mode allows learn/execute MCA tasks to be downloaded and executed; the MCA retains the learn/execute task sequence for initiation by the computer until the task is specifically erased. The learn/execute mode is ideally suited for multiuser, multitasking environments. The immediate mode results in the MCA promptly executing the command as received; the commands are single-function in nature and no information is retained for execution later as in the learn/execute mode.

To readily implement the machine-level programming requirements of the communications protocol, Canberra offers optional FORTRAN callable I/O routines for the 8673 interfaces. The RT/FT8673 package is for use with the DEC RT-11 operating system and with the Canberra-supplied RT/TSX time-sharing extension to RT-11. RSX/FT8673 is for use with the RSX-11M multiuser operating system. These I/O routines allow programs written in FORTRAN (or assembly language) to control all functions of the Series-80 multichannel analyzer. With these I/O routines, a 4096-channel spectrum can be transferred to/from a PDP-11 disk (RL01) file in less than 10 seconds.

Specifications

DATA TRANSMISSION

SIGNALS - EIA RS-422 levels.

BAUD RATE - Up to 57.6K baud; DIP switch selectable as 110, 300, 1200, 4800, 9600, 19.2K, or 57.6K.

MAX. CABLE LENGTH - ≤4000 ft. (1.2 km); standard cable length is 25 ft.

PARITY - Even, odd, or no parity bit; DIP switch selectable.

DATA ENCODING - Binary or ASCII; program controlled.

DATA FORMAT - 1 Start Bit, 8 Data Bits, 1 or no Parity Bit, 1 or 2 Stop Bits; DIP switch selectable.

DATA-BUFFERS - Input data is buffered into a 64-character First-In First-Out (FIFO) buffer.

CONTROL (8673) - Firmware controlled according to defined communications protocol; on-board Read-Only Memory (ROM) contains the firmware program necessary to correctly encode and decode the 8-bit bytes transmitted to and received from the 8673C or 8673V in the PDP-11 computer.

CONTROL (8673C & 8673V) - Program controlled by software in the PDP-11 memory (optional software available).

REMOTE ASSIGNMENT

Up to four ADCs per MCA can be individually controlled from the host computer.

EIA HANDSHAKE LINES

DATASET READY - Normally at a high state when MCA is ready to communicate with the host computer.

DATA TERMINAL READY - Used by MCA to check the status of the host computer. A high state indicates that the host is present and available.

REQUEST TO SEND - This handshake line controls serial data transmission from the MCA to the host computer. It goes low when the 64-character buffer at the host computer is full.

CLEAR TO SEND - This handshake line controls serial data transmission from the host computer to the MCA. It goes low when the 64-character buffer at the MCA is full.

LEARN/EXECUTE MODE COMMANDS

FORMAT - The commands have the following format:

Input to MCA

Byte 1	Op-Code - Unique operation code identifying command.
Byte 2	User Tag Number - An 8-bit identifier transmitted by the host computer with each command, and returned by the MCA when that particular command is acknowledged; useful in multiuser environments.
Byte 3	Message Number - An 8-bit identifier similar to User Tag Number; useful for remote multitasking.

Output from MCA

Byte 1	MCA ID - Command acknowledgement and MCA model identifier.
Byte 2	User Tag Number - Acknowledgement of Input.
Byte 3	Message Number - Acknowledgement of Input.
Byte 4	Byte Count - Number of total bytes in this MCA response.
Byte 5-N	Output Data (if appropriate) - Information as needed to respond properly to the particular op-code command.

Input to MCA

Byte 4-M	Input Data (if appropriate) - Additional information needed to specify details of the op-code command.

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Specifications(continued)

SYSTEM STATUS - Allows the host computer to interrogate the Series-80 MCA to get a complete description of the MCA (number and types of ADCs, MCA peripherals, memory size, etc.). This command is normally used during initial communication link-up.

STATUS OF ADC N - Provides the host computer with a complete description of the current state of the designated ADC or psuedo-ADC (unit "N").

STATUS OF I/O DEVICE N - Used to determine the status of an MCA I/O peripheral (unit "N").

LEARN TASK N - Used to download a learn/execute sequence of up to 64 bytes in the MCA to form a single task; the MCA stores this sequence as task "N." The functions which can be performed are the following:

Normalize
Enter ROI
Clear ROIs
Assign ADC
Start Collect
Transfer
Read Out
Jump
Execute
Clear Data
Pause
Preset PHA
Peak
Preset MCS
Strip
Smooth
Clear Time
Read In
Wait
ISO-ID (via Read Out)
ISO-QUAN (via Read Out)
Energy Calibrate (via Read In)

EXECUTE TASK N - Starts execution of the designated MCA learn/execute task.

CONTINUE TASK N - Provides a means of restarting a learn/execute task that has been prematurely halted. In particular, this command can be used for recovering from MCA power failure, data transmission errors, etc.

TEST TASK N - Provides general verification that a previously established task was "learned" correctly.

ATTACH TASK N - Used prior to downloading a learn/execute task to open or prepare a task slot for future downloading.

DETACH TASK N - Erases the designated learn/execute task.

ABORT TASK N - Aborts the designated task regardless of its operating status.

IMMEDIATE MODE COMMANDS

FORMAT - The immediate Commands have the following format:

Input to MCA

Byte 1 Op-Code - Unique operation code identifying command.
Byte 2 User Tag Number - defined as in L/E mode.
Byte 3 Message Number - defined as in L/E mode.
Byte 4 Unit Number (if appropriate) - A generic term referring to a section of MCA data memory which is to be operated upon.
Byte 5-M Input Data (if appropriate) - Input arguments necessary to completely specify the details of the operation to be performed.

Output from MCA

Byte 1-N Defined as in L/E mode.

READ OUT - Initiates read out of all spectral data between the specified channel numbers.

NEXT ROI - Returns the channel numbers defining the next ROI.

FIND CURSORS - Finds and returns the channel locations of the left and right spectrum cursors.

ENTER ROI - Enters a region of interest between the specified channel numbers.

CLEAR ROI - Clears ROI between the specified channel numbers.

START/STOP ADC - Starts or stops data accumulation.

PRESET ADC - Changes the value of the preset for the designated ADC.

CLEAR DATA - Clears data and time or clears time only.

LOCAL ENABLE/DISABLE - Permits remote disable or enable of local control via MCA console and dialogue.

8673C/8673V I/O

REGISTERS - The I/O registers are as follows:

Receiver Status Register	RCSR	7YXXX0
Receiver Buffer Register	RBUF	7YXXX2
Transmitter Status Register	XCSR	7YXXX4
Transmitter Buffer Register	XBUF	7YXXX6

Addresses are DIP switch selectable with Y = 7 or 6 and $0 \leqslant XXX \leqslant 777$. Canberra applications software uses an addressing scheme with a base device register address of RCSR = 776100 for the first MCA. For multiple MCAs, add 000010, 000020, and 000030 for MCAs two, three, and four respectively.

INTERRUPT VECTORS - Receiver 000XX0
Transmitter 000XX4

Vector addresses are DIP switch selectable with $0 \leqslant XX \leqslant 77$. Canberra applications software uses an addressing scheme with a base vector address of Receiver = 000120. For multiple MCAs, add 000010, 000020, and 000030 for MCAs two, three, and four respectively.

PHYSICAL

8673 - Printed circuit card that occupies one I/O slot in the Series-80 MCA backplane, includes a short wiring harness.

8673C - Printed circuit card that occupies one UNIBUS quad slot in the backplane of a PDP-11 (11/04, 11/34A, 11/60, 11/70, and older models), includes 25-ft. cable.

8673V - Printed circuit card that occupies one LSI-11 (Q-BUS) quad slot in the backplane of a PDP-11 (11/03 or 11/23), includes 25-ft. cable.

CABLE

8673 - Includes a short harness which terminates in a 25-pin Series-17 Amphenol female connector (designated J127) that mounts on the rear of the Series-80 MCA for all I/O signals.

8673C/8673V - Includes a 7.6-m (25-ft.) cable meeting RS-422 requirements (has twisted-pair conductors). The cable has a Berg connector on one end for mating to the 8673C/8673V and an Amphenol connector on the other end for mating to the J127 connector on the rear of the Series-80 MCA.

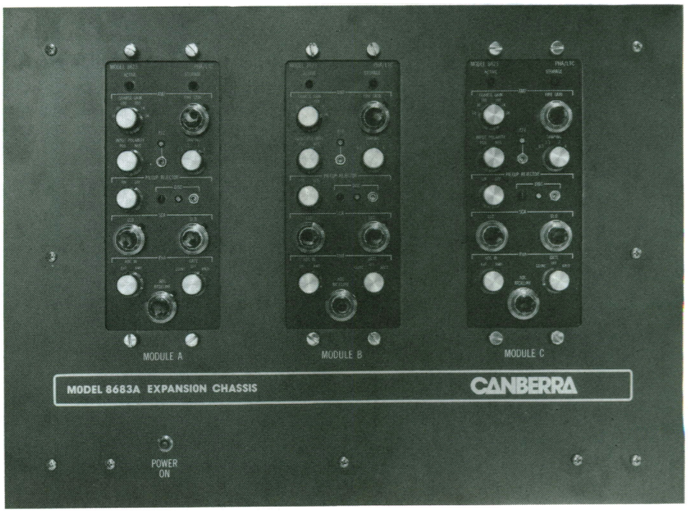
PREREQUISITE

The 8673 interface requires the Learn/Execute Option (Model 8645) in Series-80 MCA.

Model 8683A Expansion Chassis

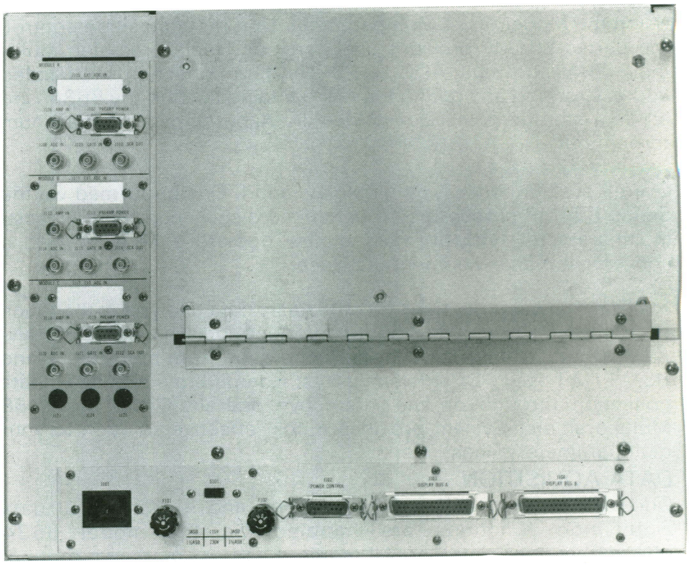
Features

- Expands Series 80 MCA to up to four (4) totally independent front end modules
- Preharnessed to accept, and provide front and rear panel access to, all Series 80 front end modules
- Internal power supply controlled by the Series 80


MODULE A
MODULE B
MODULE C
MODEL 8683A EXPANSION CHASSIS
CANBERRA
POWER ON

Description

The Model 8683A Expansion Chassis provides a convenient means of expanding the signal processing and data acquisition capabilities of the Series 80 Multichannel Analyzer. Mounting space, power, and harnessing are provided for installing any three (3) Series 80 Front End Modules. All modules are fully independent, with each having its own ADC and DMA Collect Interface to the Series 80 Display and Acquisition Bus. The 8683A includes slides for rack mounting and all needed bus and power cables to connect to the Series 80 processor.



Specifications

PHYSICAL

CAPACITY - maximum of Series 80 compatible Front End Modules.

SIZE - rack mounting with chassis slides provided; 14.0 in. (35.6 cm) high x 19 in. (48.3 cm) wide x 24.4 in. (62.0 cm) deep (behind panel) not including clearances for cables.

NET WEIGHT - 75 lbs. (34 kgs).

SHIPPING WEIGHT - 110 lbs. (50 kgs).

POWER REQUIREMENTS

105 to 125VAC or 210 to 250VAC switch selectable; 50 to 65Hz; ≈200 watts; Low Line Voltage Tap internally selected — 95/190VAC nominal.

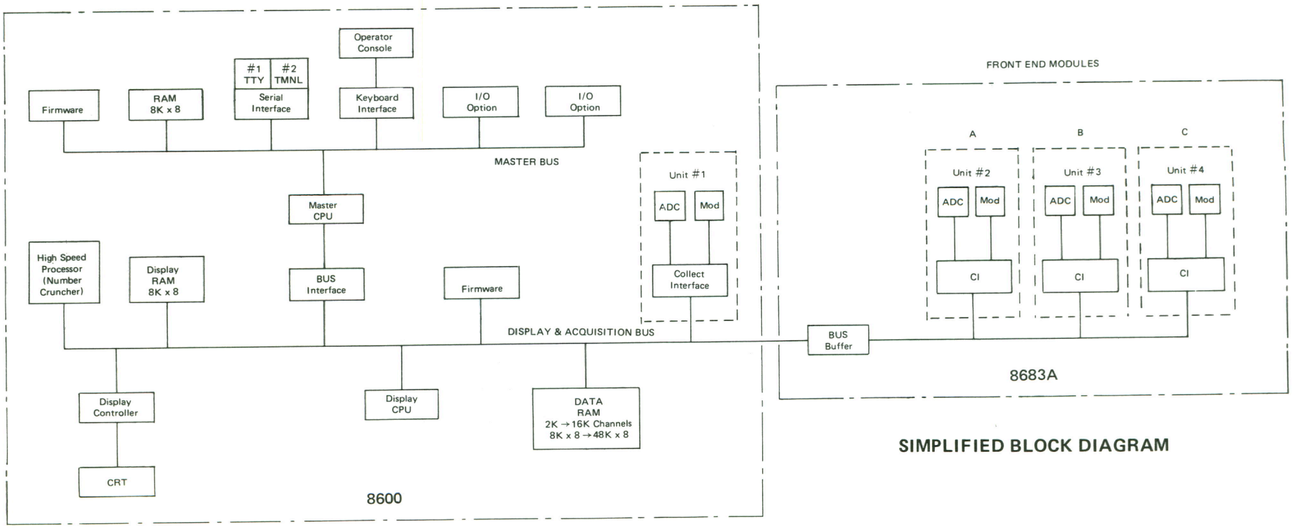
OPERATING TEMPERATURE - 0 to +45°C with adequate air flow for fan on side.

ACCESSORIES INCLUDED - a) 2 each 6 foot cables connecting the Series 80 Display Bus to the Expansion Chassis.

b) 1 each 6 foot Power Control Cable to the Series 80 or to the Model 8681 Standby Power Supply.

c) AC Line Cord; ≈7 ft.

d) Bus Buffer board that is installed in Series 80. Does not utilize any of the plug-in board slots.

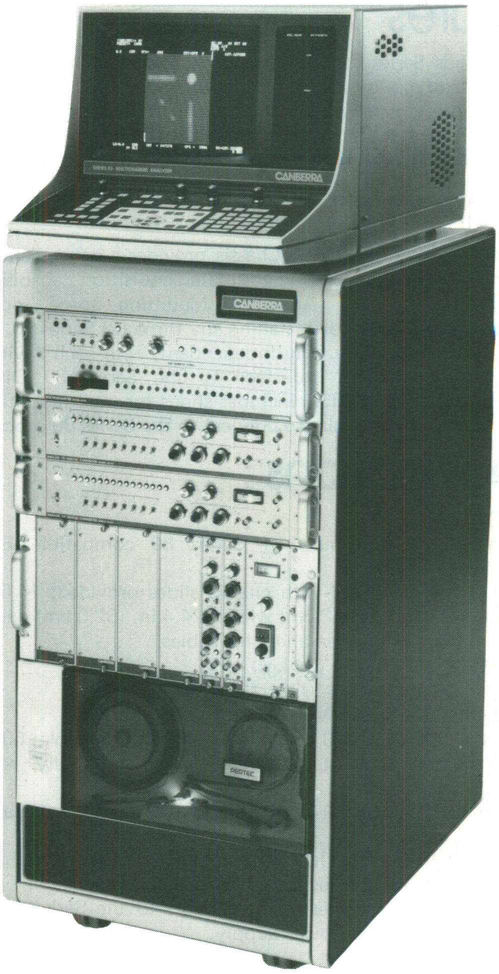

Operator Console
#1 TTY
#2 TMNL
Serial Interface
Keyboard Interface
Firmware
RAM 8K x 8
I/O Option
I/O Option
MASTER BUS
Master CPU
High Speed Processor (Number Cruncher)
Display RAM 8K x 8
BUS Interface
Firmware
Unit #1
ADC
Mod
Collect Interface
DISPLAY & ACQUISITION BUS
Display Controller
CRT
Display CPU
DATA RAM 2K → 16K Channels 8K x 8 → 48K x 8
8600
FRONT END MODULES
A
B
C
Unit #2
Unit #3
Unit #4
ADC
Mod
CI
BUS Buffer
8683A

SIMPLIFIED BLOCK DIAGRAM

Series 88 Multiparameter System

Features

- 1 to 8 Parameter Data Acquisition via External Canberra ADC's.
- Simultaneous Dual Parameter, PHA, and List Mode Acquisition.
- 8192 or optional 16,384 Data Channels.
- Independent or Dependent ADC Control, with Internal or External Coincidence Logic.
- DMA Data Acquisition Interface, for Maximum Throughput.
- Normal PHA, Isometric, and Contour Display Modes.
- Gross and Net Peak Volume Integration.
- Optional Jupiter Interface for On-line Computer Control.



Description

The Series 88 Multiparameter (MP) System provides a very cost-effective means of acquiring, displaying, and recording multiparameter data from up to eight (8) nuclear ADC's. Building upon the powerful Dual Bus, Triple Processor Series 80 architecture, the Series 88/MP system adds special purpose hardware and firmware optimized for multiparameter operation.

Using the Model 8634 Multiparameter Unit for acquisition control, the Series 88/MP provides simultaneous Dual Parameter, multi-input PHA, and multi-ADC List Mode data collection. All needed address routing and gating logic is contained within the 8634, and all data storage is via Direct Memory Access, insuring maximum throughput.

Overall system control, data display, and I/O is performed via the Series 88/MP processor. An enhanced display controller, special multiparameter firmware, and a new operator's console yield a convenient man:experiment interface.

Internal firmware functions provide basic data analysis at the touch of a button. An optional computer interface and available FORTRAN-callable subroutines allow on-line operation from both RT-11 and RSX-11M based PDP-11 family Host Computers. From basic data collection through on-line interactive operation, the Series 88 Multiparameter System provides a cost-effective solution to your multiparameter needs.

DATA AQUISITION

Once an experiment has been defined and is started, all data acquisition functions are handled via the model 8634 Multiparameter Controller. All required address mapping, routing, gating, etc. is performed in the 8634, and the resultant data points stored via DMA to the Series 88/MP data memory.

Functionally, the model 8634 acts as an intelligent, flexible interface between 1 to 8 external Canberra ADC's and an 8604/MP (8192 channels) or 8605/MP (16384 channels) Processor. Dual Parameter, Multi-Input PHA, and Multi-ADC List Mode data acquisition are all provided. And any or all modes may be active simultaniously, using the same ADC's for several modes at once if desired.

MULTI-INPUT PHA

The PHA subsection for the 8634 provides a PHA data storage facility for 1 to 8 ADC's. Each ADC may be started and stopped independently, and each has it's own Live Time Clock. Up to 16,384 data channels may be used for PHA acquisition, and are divided into 1, 2, 4, or 8 equal sized groups, depending upon the number of ADC's assigned to PHA operation. Each ADC has it's own Preset, which may be Live Time, Count in a Channel, Integral of an ROI, Net Area of an ROI, or the Counting Statistics of an ROI. In addition to this fully independent operation, some or all of the PHA ADC's may be treated as a dependent Group using either internal or external coincidence logic.

DUAL PARAMETER

Any two (2) of up to eight (8) ADC's connected to the 8634 may be selected as the X and Y coordinate inputs for Dual Parameter operation. Up to 16,384 channels may be used for Dual Parameter acquisition, allowing matrices of up to 128 x 128 to be stored.

The 8634 front panel provides a patch panel and program plug to select the desired ADC output bits to be used to generate a Dual Parameter event address. This address routing may be established with individual patch cords or via wiring in the program connector. This allows frequently used configurations to be readily established. A further level of event definition is provided by means of firmware-programmable digital restriction gating, allowing maximum resolution data collection over any energy range of interest.

SPECTRUM MULTI-SCALE

Operating as a subset of Dual Parameter, Spectrum Multiscale (SMS) replaces the Y axis ADC with a Time Base. This allows spectral decay studies, even for very short-lived nuclides, to be readily performed. SMS mode provides dwell times ranging from 1.0 msec to 9 x 10^5 sec per slice.

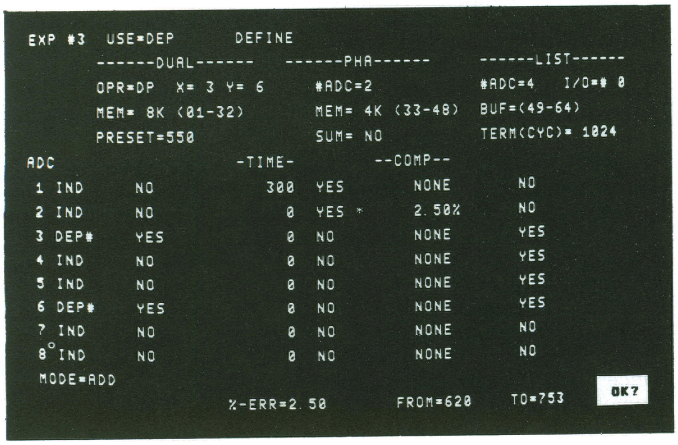
Description (continued)

LIST MODE

In List Mode, ADC conversions are stored sequentially in memory as they occur. For each conversion processed, the 8634 stores the 13-bit output of the ADC plus a 3-bit tag word to identify which of the (up to 8) ADC's generated that event. If the ADC's are being operated as independent entities, data points are simply stored on a first come-first served basis. More commonly, however, coincidence logic will be used to define a dependency among the ADC's. In this case no data is stored until the requirements of the coincidence logic are satisfied. With the 8634 the experimenter may choose either the internal coincidence logic (1 to 4 μ sec adjustable time window) or external logic gating. A unique feature of List Mode processing is automatic double buffering (ping-pong operation). The DMA interface contains all needed Logic to permit simultaneous acquisition and readout from alternate halves of the List Mode data region, insuring maximum throughput.

EXPERIMENT DEFINITION

Through the use of Experiment Definition Tables, the Series 88/MP firmware greatly simplifies the task of setting up complex multi-mode, multiparameter experiments. Using the function-oriented control panel, the experimenter simply fills in an ADC vs. Operating Mode matrix, as shown below. This completely defines the data acquisition characteristics of an experiment. Once an experiment has been defined in this manner, it may be started by selecting and activating the appropriate table. The experiment will then continue running until manually stopped or the defined preset conditions are reached.



```
EXP #3  USE=DEP      DEFINE
      ------DUAL------   ------PHA------     ------LIST------
      OPR=DP  X= 3 Y= 6    #ADC=2             #ADC=4   I/O=# 0
      MEM= 8K (01-32)      MEM= 4K (33-48)    BUF=(49-64)
      PRESET=550           SUM= NO            TERM(CYC)= 1024
ADC                 -TIME-         --COMP--
 1 IND     NO           300  YES        NONE       NO
 2 IND     NO             0  YES *      2.50%      NO
 3 DEP#    YES            0  NO         NONE       YES
 4 IND     NO             0  NO         NONE       YES
 5 IND     NO             0  NO         NONE       YES
 6 DEP#    YES            0  NO         NONE       YES
 7 IND     NO             0  NO         NONE       NO
 8°IND     NO             0  NO         NONE       NO
 MODE=ADD
                    %-ERR=2.50      FROM=620    TO=753    OK?
```

Memory space is provided for up to four (4) separate Experiment Definition Tables. Each is initially entered from the Operator's Console. The experimenter may then edit them as desired, and save them on an I/O storage device for later loading and reuse. This allows complex procedures to be established and tested, and then saved for repeated usage in the future.

The Experiment Definition Tables also provide a convenient means of describing the experiment to an operator. At a glance, he can readily determine which ADC's are being used, which are operating as members of a Dependent Group, the types of data acquisition to be performed, etc. A complete overview of the experiment to be performed.

At any given time, the Series 88/MP can be executing any one experiment of the four (4) that may be defined. But since one experiment can include all three acquisition modes, PHA, Dual Parameter, and List Mode data acquisition can be in process at the same time. And as the example below shows, some ADC's may be operating in several modes simultaneously; others may be in a single mode only. The choice is strictly up to the experimenters' wishes, and how he defines the table.

By combining Experiment Definition with Learn/Execute, experiments that are frequently performed can be automated to a very high degree. The operator need only load the needed tables and sequences from tape, and Execute them.

For a completely automated system, the available 8673/MP Jupiter Networking Interface allows complete PDP-11 family Host Computer Control. Experiment Definition Tables and Learn/Execute sequences can be down-loaded and started from the Host, providing completely unattended operation, if desired.

DISPLAY AND ANALYSIS

A large, high quality CRT display is an asset on any MCA. And for Dual Parameter work, with its' three dimensional data, it is a must. In this regard the Series 88/MP System excels.

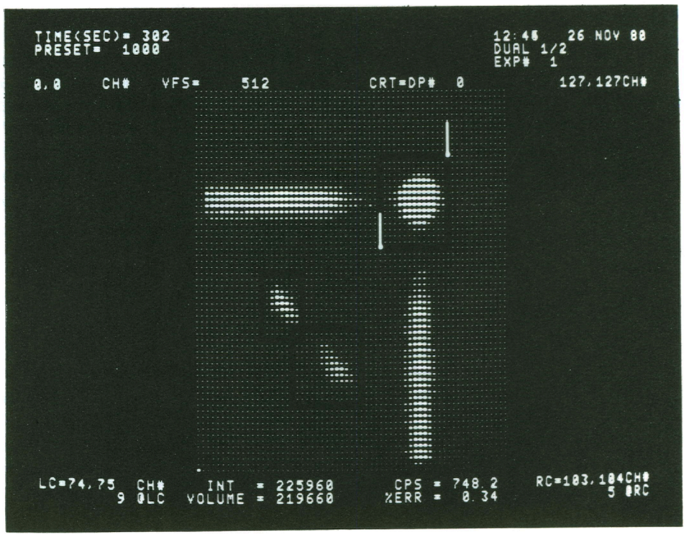
PHA DATA

When displaying a PHA data region, the Series 88/MP provides the same flexible display and analysis functions that are found in the standard Series 80. Multiple Intensified Regions of Interest, dual trace Horizontal Expansion, Autoranging Vertical Full Scale, etc. are all included.

For analyzing PHA data, all standard Series 80 analysis functions are provided. Data manipulation is handled via the three or five point Smooth, Fractional Spectrum, Stripping, and Normalization. Peak analysis operations include Energy Calibration (first or second order), Peak Net Area with End Point Averaging, and an Automatic Peak Seek. All are controlled from clearly labelled function buttons on the Operator's Console.

DUAL PARAMETER DATA

Both Contour and Isometric display modes are provided for Dual Parameter data. With either, spectra of up to 16,384 channels (128 x 128) may be displayed. Both present the data in a three dimensional format, and the operator can select either at the push of a button.



```
TIME(SEC)= 302                                   12:45    26 NOV 80
PRESET=  1000                                    DUAL 1/2
                                                 EXP#  1
0.0    CH#   VFS=    512          CRT=DP#  0          127,127CH#

LC=74.75  CH#     INT    = 225960      CPS = 748.2    RC=103,104CH#
        9 0LC   VOLUME = 219660      %ERR =  0.34              5 0RC
```

CONTOUR DISPLAY

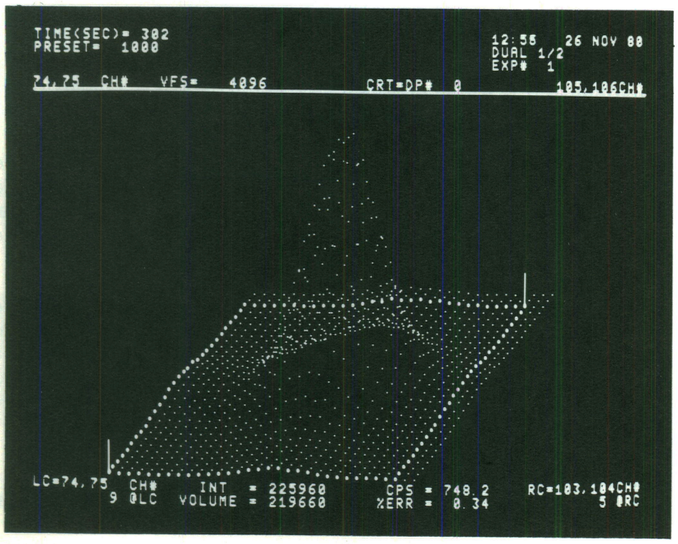
Contour mode is illustrated above. The X and Y ADC addresses generate the X and Y display axes. The Z axis is the number of counts, and is represented by a varying intensity level; the greater the intensity, the more counts at that location. Series 88/MP provides six (6) different intensity levels for representing the data, plus a separate level to mark the boundaries of Regions of Interest. The net result is a display capability ideally suited to visual analysis of complex Dual Parameter spectra.

Description (continued)

To aid in analyzing the data, the Series 88/MP firmware provides gross Peak Integral plus net Peak Volume and the Counting Statistics. These functions, combined with Multiple Regions of Interest, allow the operator to quickly determine the characteristics of his data.

ISOMETRIC DISPLAY

All Dual Parameter data may also be displayed in the traditional three dimensional Isometric mode. As shown below, the Z axis (count) is displayed via vertical displacement from the X, Y plane.



```
TIME(SEC)= 302                                     12:55   26 NOV 80
PRESET=  1000                                      DUAL 1/2
                                                   EXP#  1
74,75  CH#    VFS=    4096           CRT=DP#  0              105,106CH#

LC=74,75  CH#    INT    = 225960        CPS  = 748.2     RC=103,104CH#
        9 @LC  VOLUME = 219660        %ERR =  0.34              5 @RC
```

To aid in interpreting the data, several display manipulation functions are provided for the Isometric display mode. Display rotation allows the data to be viewed from any of five different angles. Expansion allows the operator to select a 32 x 32 subset (out of a maximum of 128 x 128) of the data for full scale display, enabling details to be more closely examined. And for even more detailed work, just one or a few slices of data may be selected for display.

Like Contour, Isometric display also includes multiple Regions of Interest, gross Peak Integral, and net Peak Volume with Counting Statistics. A complete set of firmware functions for rapidly analyzing Dual Parameter data.

LIST MODE MONITOR

Due to the nature of the data - a sequential list of ADC events - there really is no special need to view list data being accumulated; the display would have litle meaning. However, a means of monitoring the incoming data to insure the experiment is operating correctly is highly desirable. On the Series 88/MP this is readily performed via the List Mode Monitor.

Operating as a subset of PHA data acquisition, the List Monitor allows the operator to select any ADC for simultaneous PHA and List Acquisition. Using a switch on the 8634 unit, the operator can readily monitor each ADC in an experiment to determine proper operation. Since all List data is full 13 bit resolution (8192 channel gain), a digital compression switch is included to tailor the List Monitor Display to the memory assigned for monitoring purposes. Because of this as few as 1024 data channels can handle the monitoring functions for an eight (8) input 16,384 channel List Mode experiment.

INPUT/OUTPUT

For PHA and Dual Parameter data a wide range of hard copy and bulk storage devices are available: The standard TTY/EIA interface readily handles most low to medium speed terminals. Available I/O cards allow fast printer, X-Y and Graphics Plotters, Paper Tape, Magnetic Tape, and Cassette to be readily added. All are data and format compatible with the standard Series 80.

Due to the normally high and voluminous data rates associated with List Mode processing, several special I/O features have been developed. First, all List Mode acquisition is double buffered, providing simultaneous acquisition and readout from alternate halves of the list mode data region (ping-pong operation). Next, the available 8661/MP Magnetic Tape Controller has been designed to drive two tape transports, and will automatically switch to the second transport when the first tape is full. The net result is a system optimized for logging large volumes of high rate data.

For List Mode applications with lesser data logging demands, an available paper tape punch and interface may be used. Here, too, double buffering is provided to minimize system latencies. Or, for on-line systems, the data may be transmitted directly to a Host CPU. Your choices are experiment dependent, not system limited.

COMPUTER CONTROL

For the ultimate in an on-line computer controlled Multiparameter System, the optional 8673/MP Jupiter Computer Networking Interface is the answer. Operating at a line rate of 57.6k Baud, the RS-422 8673/MP can be used to interface the Series 80/MP to any of a wide range of PDP-11 family Host CPU's. From the low-cost PDP-11/03 to the powerful PDP-11/70, the experimenter can choose exactly the level of capabilities he needs.

Once the Series 88 is on-line, the Host Computer can control a complete experiment. Down loading of Experiment Definition Tables and Learn/Execute Sequences, experiment initiation and termination, data read in and readout. All under Host control. And all programmable from either RT-11 or RSX-11M FORTRAN-IV with the available FORTRAN-callable I/O drivers.

Item	Series 30	Series 40	Series 80
Tag Word Generator	N/A	Standard Feature	Standard feature
External ADC Interface (for 8060, 8070, 8070A or 8080 ADC)	N/A	Requires 4223	8633
Digital Stabilizer	N/A	4233 Requires external ADC	8200 Requires external ADC
Mixer Router	8220A Requires 3100 - 06	8220A Requires 4231 (8220 for external ADC)	8624 (8220 for external ADC)
Multi-input Multichannel Scaling	8220A Requires 3100 - 06	8220A Requires 4231	Multiple 8622's Requires 8683A
Multiple ADC's	N/A	8420 Requires 4223	8683A and any ADC's
Dual Parameter	N/A	N/A	N/A
Magnetic Tape Controller	N/A	7 track: 8531A 9 track: 8531A/9 Requires: I/F	8661
Standby Battery Pack for Semiconductor Memory	N/A	8681	8681
Camera	HC - 1	HC - 2	
Carrying Case	CC31	Consult Factory	Consult Factory
Battery Inverter	RPS - 310	RPS – 310	N/A

Model 8070/8070A Analog-to-Digital Converter

ANALOG TO DIGITAL CONVERTER MODEL 8070
POWER
ADC CONVERSION
DIGITAL BASELINE
GAIN
RANGE
ANALOG BASELINE
DISCRIMINATORS
LLD
ULD
% DEAD TIME
SCA OUTPUT
GATE
COINC
ANTI
INPUT DIRECT COUPLED
CANBERRA

Features

- Self-contained rack mount package with built-in power supply; requires no costly NIM bin space
- Full 8192 channel conversion gain and range
- 50MHz (8070) or 100MHz (8070A) clock rate
- Digital offset selectable from 0 to 8160 channels in increments of 32 channels
- Integral non-linearity $<\pm 0.025\%$
- Drift $<\pm 0.005\%$ per ^{o}C
- LED indicators for overflow, invalid conversion, and binary value of the converted pulse

Description

The 8070 and 8070A are rack-mounted self-powered analog-to-digital converters for applications in nuclear and X-ray spectroscopy. Based upon the ADC from the Model 8100 MCA, the 8070 and 8070A provide state-of-the-art linearity at an unbeatable performance: price ratio.

Both ADC's provide a full 13 bits (8192 channels) of resolution via a Wilkinson-type pulse height to time converter with a 50MHz (8070) or 100MHz (8070A) clock rate. A Gate Input is provided for Coincidence/Anti-coincidence Operation (Early or Late) and Analog Sampling.

Front and Rear Panel BNC connectors are provided for Signal Input, Gate Input, and the independent SCA Output. Front Panel Test Points are included for all three signals.

The 8070 and 8070A are compatible with all Canberra and Geoscience storage units. For the 8100 and 8180 MCA's, the External ADC Interface (Option 17) is required; for SCORPIO, the 8825 ADC Expander is required; for the Series 80 MCA the 8633 External ADC Interface is required. The 8070 and 8070A are also fully compatible with the Canberra 8440A Dual Parameter Unit, the 8420 ADC Multiplexer, the 8220 Mixer/Router, the 8200 Digital Stabilizer and the 8241 ADC Time Base ensuring maximum flexibility and versatility.

Specifications

INPUT

SIGNAL IN - Accepts positive unipolar or bipolar (positive lobe leading) pulses or DC levels; amplitude 0 to +10 volts; rise time 0.25 to 30μsec (longer on request): width 1μsec minimum; $Z_{in} \approx 1.35$K ohms; DC coupled; Front and Rear Panel BNC connectors; Front panel test point

GATE IN - Accepts positive logic pulse or DC level; amplitude +2.5 to +7V; width >100 nanoseconds; DC coupled; Front and Rear Panel BNC connectors; Front Panel Test Point

OUTPUTS

DATA - 25-pin Amphenol # 17-10250-1 connector containing signals to memory unit

STABILIZER - 25-pin Amphenol #17-10250-1 connector containing signals to parallel input stabilizer such as the Canberra Model 8200

SYSTEM BUSY - Provides +4VDC level during system dead time; Rear Panel BNC connector

SCA - Logic pulse output (1 = +4V) when ADC Input signal is between LLD and ULD; operates independent of ADC; width $\approx 0.5\mu$sec; $Z_{out} \approx 50$ ohms; Front and Rear Panel BNC connector; Front Panel Test Point

CONTROLS

POWER - Front Panel locking toggle switch; applies AC power to unit

CONVERSION GAIN - Six position rotary switch to select full scale resolution of input signal; selection of 256, 512, 1024, 2048, 4096, or 8192 channels for 10V input

RANGE (Overflow) - Six position rotary switch to select 256, 512, 1024, 2048, 4096, or 8192 addresses for storage

DIGITAL BASELINE - Eight toggle switches to provide supression of digital zero; 0 to 8160 channels in multiples of 32 channels; at 256 or 512 Conversion Gain, digital offset equals the switch setting times 1/4 or 1/2 respectively

ANALOG BASELINE - Ten-turn locking potentiometer to vary analog zero; range ±6% of input range; resolution $<0.005\%$ of full scale

Specifications(continued)

LOWER LEVEL DISCRIMINATOR - Ten-turn locking potentiometer sets lower limit of ADC and SCA window range 0 to 110% of full scale; linearity not effected to within 10mV of LLD setting; resolution and resetability <0.05%

UPPER LEVEL DISCRIMINATOR - Ten-turn locking potentiometer sets upper limit of ADC and SCA window; range 0 to 110% of full scale; resolution and resetability <0.05%

GATE - Two position toggle switch to select Coincidence or Anticoincidence operation; if no input is connected to Gate In, analysis is enabled regardless of switch position; if a Coincidence Signal is connected, a positive pulse during the Linear Gate Time is required to enable conversion (Late Coincidence); in Anticoincidence, gating occurs at the time the input signal rises through the LLD (Early); internal jumpers are provided for Early Coincidence and Analog Sampling operation

INDICATORS

POWER - Indicates status of AC power

INVALID - Indicates an invalid ADC conversion

OVERFLOW - Indicates overflow conversion (ULD or Range)

CONVERSION - 13 indicators to display the binary value of a conversion

DEAD TIME - Meter to display the average percentage of ADC dead time

PERFORMANCE

SCA

TIMING - Output pulse generated when input pulse falls through LLD

INTEGRAL NON-LINEARITY - <±0.25% of full scale

DRIFT (LLD OR ULD) - <±0.005% full scale/°C

OFFSET FROM ADC WINDOW - <0.5% of full scale

PULSE PAIR RESOLUTION - <1μsec

ADC

CONVERSION TIME

8070: 2.5 + 0.02 (N + X) μsec

8070A: 2.5 + 0.01 (N + X) μsec where N = Address and X = Effective Digital Baseline; for 256 and 512 Conversion Gain the (N + X) value is multiplied by 4 or 2 respectively

LINEAR GATE TIME - Constant Fraction Peak Detector closes gate after peak roll-over (≈90% of peak)

ADC DEADTIME - Linear Gate Time + Conversion Time + Memory Cycle Time

INTEGRAL NON-LINEARITY - <0.025% over top 99% of full scale range

DIFFERENTIAL NON-LINEARITY

<±0.75% over top 99% of range

DRIFT

Gain: <±0.005% of full scale/°C

Zero: <±0.005% of full scale/°C

Long Term: <±0.01% of full scale/24 hrs. at a constant temperature

PEAK SHIFT - <±0.025% of full scale at rates to 50kHz

CHANNEL PROFILE

8192 Gain : flat over >80% of channel width

Other: flat over >90% of channel width

AUTOMATIC RELEASE - Internal logic prevents system lockup; ADC is reset if converted data not accepted within ≈10msec.

POWER REQUIREMENT

105 - 125 or 210 - 250 VAC (Switch selectable)
50-400Hz
25 Watts

PHYSICAL

SIZE - Standard 19 inches rack mounted; (3.5 inches high by 18 inches deep) (8.89 cm x 45.72 cm)

NET WEIGHT - 18 lbs. (8.2 kgs)

SHIPPING WEIGHT - 35 lbs. (15.8 kgs)

ACCESSORIES

Four (4) foot cable for connection to Canberra Memory Unit supplied with ADC

OPTIONS

8070/8070A-01 - Live time corrector wiring for use with 2013 amplifier.

Model 8075
Analog-to-Digital Converter

Features

- Full 8192 channel conversion gain and range
- Synchronized, crystal controlled 100 MHz clock rate
- Stability better than ±0.009% of full scale/°C
- Pulse pileup rejection input
- Pulse height analysis using either automatic peak detection or delayed triggering
- Analog sampling voltage analysis
- Digital offset in 128 channel increments

Description

The Canberra Model 8075 is a single width NIM style analog to digital converter for applications in nuclear and X-ray spectroscopy. This unit incorporates a Wilkinson type counter-ramp converter with a clock rate of 100 MHz for fast operation. The binary TTL-compatible output is three-stated, and can be set for positive true or negative (logic low) true to address the computer or MCA interface as required.

A direct coupled input of 0 to +10V is digitized according to the front panel GAIN control into binary code spans of 8 thru 13 bits (256 thru 8192 channels). The concentric RANGE control may be used to limit the maximum digital output count to less than the full scale set by the GAIN control. This is useful when data is to be transferred to a memory unit with a smaller capacity than the overflow limit of the selected gain range. The user may expand an analog input region for finer gain analysis by using a high GAIN setting and selecting appropriate digital OFFSET in any desired combination of the 6 front panel toggle switches.

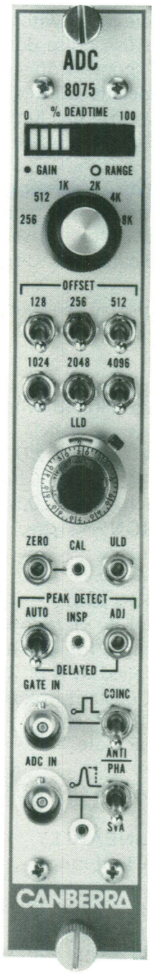
The Model 8075 includes a 10 turn locking dial potentiometer for the Lower Level Discriminator (LLD) with a range of 0.02 to 10 VDC, and a screwdriver adjusted 22 turn Upper Level Discriminator (ULD) with a range of 0.02 to 10.5 VDC nominal. The front panel ZERO adjustment is also a 22 turn screwdriver adjusted potentiometer; its setting can be monitored on the adjacent CAL test point and covers ±5% of full scale input range.

Conversion for the Pulse Height Analysis (PHA) mode can be initiated AUTOmatically using an internal constant fraction peak detector operating on the trailing edge of the input pulse, or can be DELAYED up to 100μSec after the leading edge of the input pulse passes the LLD. A front panel INSPect test point is provided so that the user can monitor the Linear Gate (LG) time between LLD crossing and the beginning of conversion for either mode. Conversions may be enabled/disabled by the COINCidence/ANTIcoincidence gating applied at any time during the Linear Gate interval.

Conversion for the Sample Voltage Analysis (SVA) mode is initiated by the falling edge of a GATE pulse applied in the COINCidence mode. The same LLD and ULD limits are used for acceptance of an input level for conversion in this mode.

The Model 8075 is compatible with all Canberra MCA's using the external ADC options designated for each unit. This instrument is also compatible with the Canberra Models 8440A and 8634 for multiple parameter studies, the Model 8420 Multiplexer, and Model 8220 Mixer/Router. A separate 25 pin STABILIZER output connector on the rear panel interfaces with the Model 8220 Digital Stabilizer for use in system setups requiring gain stabilization. An additional 3 pin pileup rejector (PUR) connector is provided on the rear panel for direct interface to the Canberra Model 2013 and 2020 Amplifiers which have pileup rejection circuitry built into them.

Normal interfacing distances of up to 2 meters are accommodated from the internal data transfer logic. For longer distances a special termination cable is available as an option so that interference and crosstalk in the data lines is properly suppressed.



Specifications

INPUTS

ADC IN - accepts positive unipolar or bipolar (positive lobe leading) pulses for PHA, or DC level for SVA mode; amplitude 0 to +10V, +12V maximum; rise time 0.25 to 100μSec maximum; width 0.5μSec minimum; input impedance 1K ohm, direct coupled; front panel BNC and test point.

GATE IN - accepts positive logic pulse or DC level; amplitude ⩾ 2.5 to 7 volts maximum; DC coupled; with coincidence or SVA selected loading ⩽ -100 μ A at +3 volts and ⩽ +800μA for anti-coincidence; width ⩾250 nsec; PHA analysis does not require a gate input. For SVA, pulse width ⩾ 1μsec.

OUTPUTS

DATA - provides the 13 binary TTL-compatible output lines and the data transfer commands required for MCA interface; rear panel 25 pin block connector and mating cable with Amphenol type #17-10250 connector. (2 meters standard; specify if for longer distances.) (Data lines are logic low for true as standard; specify if for logic high true.)

Specifications(continued)

STABILIZER - provides the 13 binary TTL-compatable lines and the trigger commands required for the Model 8200 Digital Stabilizer; rear panel 25 pin block connector and mating cable with Amphenol type #17-10250 connector. (2 meters standard; specify if for longer distances.) (Data lines are logic low for true as standard; specify if for logic high true.)

PILEUP REJECTOR/LIVE TIME CORRECTOR - Accepts REJECT and Live Time signals from Canberra Model 2013 or 2020 Amplifiers, also provides Linear Gate to that unit for full interactive operation; rear panel 3 pin Molex connector.

REJECT - receives a positive logic pulse used to initiate an ADC reject sequence; must occur during the ADC's Linear Gate (LG) time; amplitude ≥ 2.5 to 7 volts; width ≥ 50 nsec; loading ≤ +800μA at +3 volts. Accessible through pin 1 of rear panel PUR connector.

$\overline{\text{LG}}$ - Provides a negative true logic signal; logic low when ADC accepts input, returns to a logic high at the ADC acquisition cycle conclusion. TTL compatable totem pole output (LS) through 47 ohm series resistor. Accessible through pin 2 of rear panel PUR connector.

DEAD TIME - rear panel BNC connector having a dual-function capability, external dead time INPUT or ADC dead time OUTPUT; one of these modes is internally selected with a jumper plug; shipped in the NEG INput position.

When used as:

NEG INput - accepts a negative logic signal which is "ORed" with the ADC dead time, the composite dead time signal may be accessed through pin 21 of the rear panel DATA connector; logic low when true; amplitude ≤400 mV, 0 to +7 volts maximum; loading ≤ -1.4 mA at 400 mV.

OUT - provides logic signal representation of the ADC acquisition and conversion times; internal jumper plug provides the option of positive true or negative true logic pulses; shipped in the POS position; TTL compatible, totem pole output (LS) with 4.7k pull up resistor.

FRONT PANEL CONTROLS

GAIN - six position rotary switch to select full scale resolution of input signal; selection of 256, 512, 1024, 2048, 4096 or 8192 counts (channels) for a 10V input pulse or level.

RANGE - six position rotary switch to select 256, 512, 1024, 2048, 4096 or 8192 counts as the overflow limit and the limit of the address output lines to be driven.

OFFSET - six toggle switches to provide suppression of the digital zero; 0 to 8064 channels in multiples of 128 channels.

LLD - ten turn locking dial potentiometer sets the Lower Level Discriminator for the minimum input acceptance voltage; range 0.02 to +10 VDC.

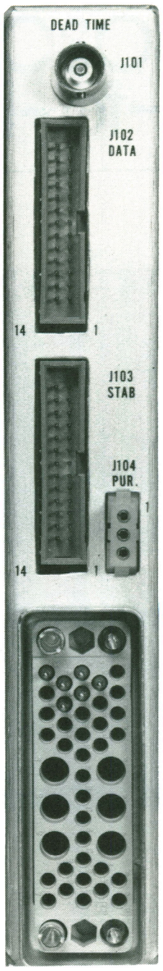
ULD - screwdriver adjusted 22 turn potentiometer sets the Upper Level Discriminator for the maximum input acceptance voltage; range 0.02 to +10.5 VDC.

ZERO - screwdriver adjusted 22 turn potentiometer sets the input analog zero level; range ±5% of input range; resolution 0.005% of full scale. Adjacent CALibration test point monitors adjustment voltage.

PEAK DETECT - toggle switch to select either AUTOmatic peak detection to initiate conversion cycle using internal constant fraction trigger on the falling edge of the input pulse, or DELAYED using a fixed time after the input passes the selected LLD. An ADJustment potentiometer permits selection of from 1 to 100μSec delay. An INSPect test point provides a monitor of the Linear Gate time for either adjustment of the desired delay, or for time sync of an applied GATE pulse input.

COINC/ANTI - toggle switch to select either a COINCidence or an ANTIcoincidence mode of the GATE input pulse to enable or to disable respectively a given conversion cycle. Pulse must be present during the Linear Gate time as monitored on the INSPect test point.

PHA/SVA - toggle switch to select either Pulse Height Analysis or Sample Voltage Analysis modes of conversion. In PHA the input pulse must transition thru the LLD to be accepted for conversion. In SVA a varying input DC level is acquired while the GATE input is high, and captured for conversion on the negative (falling) edge of the GATE input.



INDICATORS

DEAD TIME - ten segment LED indicator displays the average dead time of the converter.

PERFORMANCE

INTEGRAL NONLINEARITY - less than ±0.025% of full scale over the top 99% of selected range.

DIFFERENTIAL NONLINEARITY - less than ±1% over the top 99% of range.

DRIFT - Gain - less than ±0.009% of full scale/°C
Zero - less than ±0.0025% of full scale/°C
Long Term - less than ±0.005% of full scale/24 hours at a constant temperature.

PEAK SHIFT - less than ±0.025% of full scale at rates up to 50KHz.

ADC DEAD TIME - Linear Gate Time + Conversion Time + Memory Cycle Time.

CONVERSION TIME - 3 μSec + 0.01 (N + X) μSec where N=address count, and X = effective digital OFFSET.

CHANNEL PROFILE - typically flat over 90% of channel width.

POWER REQUIREMENTS

+24V	- 75mA	+12V	- 240mA
-24V	- 75mA	+12V	- 180mA

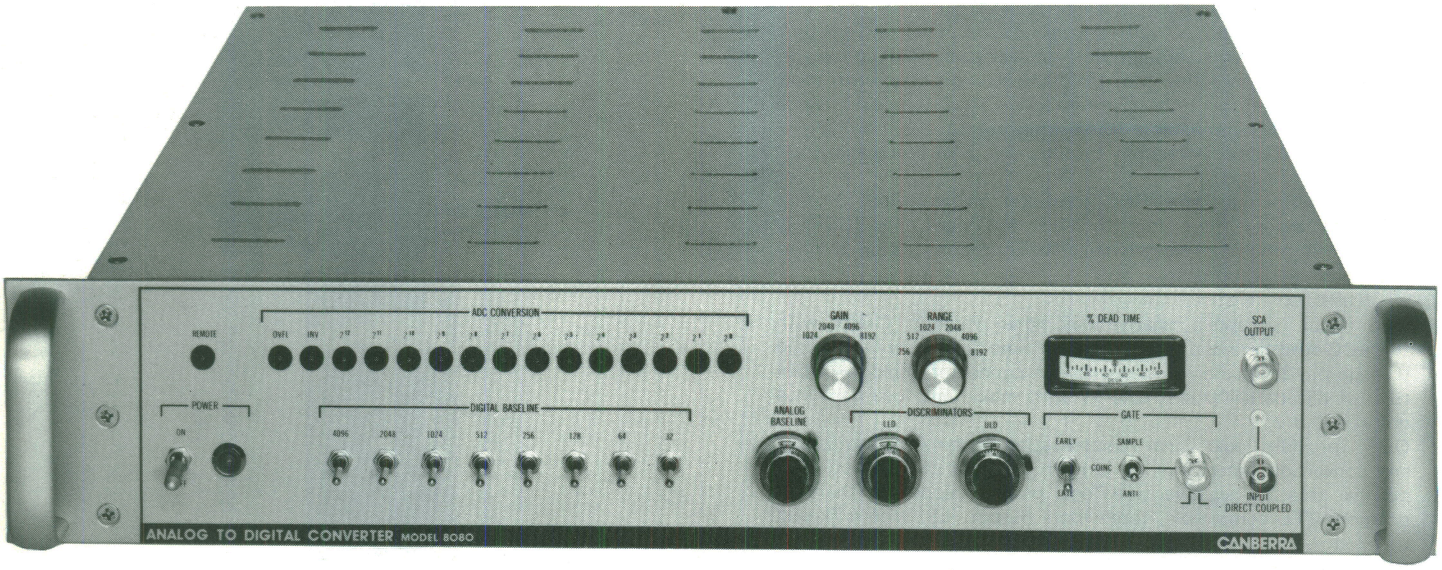
PHYSICAL

SIZE - standard single width NIM module (1.35 x 8.71 inches) (3.42 x 22.13 cm) per TID-20893 (rev.)

NET WEIGHT - 1.9 lbs. (0.9kg).

SHIPPING WEIGHT - 40 lbs. (1.8kg).

Model 8080
Analog-to-Digital Converter


ADC CONVERSION
REMOTE
OVFL
INV
GAIN
RANGE
% DEAD TIME
SCA OUTPUT
POWER
ON
DIGITAL BASELINE
4096
2048
1024
512
256
128
64
32
ANALOG BASELINE
DISCRIMINATORS
LLD
ULD
GATE
EARLY
LATE
SAMPLE
COINC
ANTI
INPUT DIRECT COUPLED
ANALOG TO DIGITAL CONVERTER MODEL 8080
CANBERRA

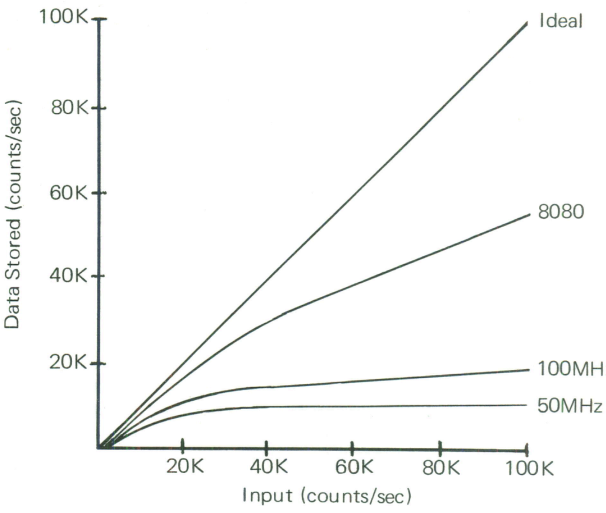
Features

- $<10\mu$sec average conversion rate
- Full 8291 channel conversion gain and range
- Constant fraction peak detector ensures minimum pulse processing time
- Internal data buffer allows simultaneous signal conversion and data storage
- Integral nonlinearity $<\pm 0.025\%$
- Drift $<\pm 0.005\%$ per ^{o}C
- Digital offset from 0 to 8160 channels in 32 channel increments
- Self-contained rack mount package with built-in power supply

Description

The Model 8080 is a ***Fast*** Analog to Digital Converter designed specifically to provide optimum performance in high count, high resolution application. With an average conversion rate of $<10\mu$sec, an internal data buffer, and a constant fraction peak detector, the 8080 offers over 5 times the pulse processing efficiency of a standard 50MHz ADC. Figure 1 graphically illustrates this efficiency by comparing the system throughput (input counts/sec vs. stored counts/sec) of the 8080 to typical 50MHz and 100MHz Wilkinson-type ADC's.

In addition to providing maximum system throughput, the 8080 also offers a full complement of operating controls and indicators to ensure maximum flexibility Both front and rear panel connectors are provided for Signal In, Gate In, and SCA Out. The Linear Gate may be set for Early or Late Coincidence/Anticoincidence as well as Analog Sampling operation Front panel Test Points plus LED Indicators for Converted Value, Invalid Conversion, and Overflow simplify experimental setup.



All data taken at 8192 Conversion Gain with Cs-137 (661.6KeV) into channel #6144.

Figure 1. ADC Throughput

The 8080 is fully compatible with all Canberra and Geoscience data storage units and accessory modules such as the 8440A Dual Parameter Unit, 8420 ADC Multiplexer, 8241 Time Base, 8220 Mixer/Router, and 8200 Digital Stabilizer.

Specifications

INPUT

SIGNAL IN - Accepts positive unipolar or bipolar (positive lobe leading) pulses or DC levels; amplitude 0 to +10 volts; rise time 0.25 to 30µsec (longer on request): width 1µsec minimum; Z_{in}≈1.35K ohms; DC coupled; Front and Rear Panel BNC connectors; Front Panel Test Point.

GATE IN - Accepts positive logic pulse or DC level; amplitude +2.5 to +5V; width >100 nanoseconds; DC coupled; Front and Rear Panel BNC connectors.

OUTPUTS

DATA - 25-pin connector containing data and control signals to memory unit.

STABILIZER - 25-pin connector containing data and control signals to parallel input stabilizer such as the Canberra Model 8200.

SYSTEM BUSY - TTL logic output; provides high level during system dead time; Rear Panel BNC connector.

SCA - Positive logic pulse output (1 = +5V) when ADC Input signal is between LLD and ULD; internally selected +8V output, operates independent of ADC; width ≈0.5µsec; Z_{out} ≈50 ohms; Front and Rear Panel BNC connector.

CONTROLS

POWER - Front Panel locking toggle switch; applies AC power to unit.

CONVERSION GAIN - Four position rotary switch to select full scale resolution of input signal; selection of 1024, 2048, 4096 or 8192 channels for 10V input.

RANGE (Overflow) - Six position rotary switch to select 256, 512, 1024, 2048, 4096 or 8192 addresses for storage.

DIGITAL BASELINE - Eight toggle switches to provide suppression of digital zero; 0 to 8160 channels in multiples of 32 channels.

ANALOG BASELINE - Ten-turn locking potentiometer to vary analog zero; range ±6% of input range; resolution <0.005% of full scale.

LOWER LEVEL DISCRIMINATOR - Ten-turn locking potentiometer sets lower limit of ADC and SCA window; range 0 to 110% of full scale; linearity not effected to within 10mV of LLD setting; resolution and resetability <0.05%.

UPPER LEVEL DISCRIMINATOR - Ten-turn locking potentiometer sets upper limit of ADC and SCA window; range 0 to 110% of full scale; resolution and resetability <0.05%.

GATE - If no input is connected to Gate In, PHA is enabled in either Coincidence or Anticoincidence switch positions independent of the Early/Late switch; if a signal is connected to Gate In, a positive pulse is required to enable conversion when Coincidence is selected while the same pulse will disable a conversion when Anticoincidence is selected; Early requires a gating pulse at the LLD crossing and Late requires a gating pulse during the Linear Gate Time; Sample is independent of the Early/Late switch and requires a positive gating pulse >500ns to properly acquire the analog input.

INDICATORS

POWER - Indicates status of AC power.

INVALID - Indicates an invalid ADC conversion.

OVERFLOW - Indicates overflow conversion (ULD or Range).

CONVERSION - 13 indicators to display the binary value of a conversion.

REMOTE - Option which indicates Gain, Range and Digital Offset are under external control; special interface required; consult factory for details.

DEAD TIME - Meter to display the average percentage of ADC dead time.

PERFORMANCE

SCA

TIMING - Output pulse generated when input pulse falls through LLD. In sample mode, no SCA output is generated.

INTEGRAL NON-LINEARITY - <±0.25% of full scale

DRIFT - (LLD or ULD)

<±0.05% full scale/°C
<±0.01% full scale/24 hours at constant temperature

OFFSET FROM ADC WINDOW - None

PULSE PAIR RESOLUTION - <1µsec

ADC

CONVERSION TIME - 6µsec + x (independent of Conversion Gain).

- Where x is pseudo-random and varies from 0 to 7µsec
- Average <10µsec

LINEAR GATE TIME - Constant Fraction Peak Detector closes gate after peak roll-over (≈90% of peak).

INTERNAL DATA BUFFER - Allows the ADC to convert a newly acquired input while simultaneously transferring the last data conversion to the memory storage unit.

ADC DEAD TIME - Linear Gate Time and Conversion Time.

INTEGRAL NON-LINEARITY - <±0.025% over top 99% of full scale range.

DIFFERENTIAL NON-LINEARITY - <±1.0% over top 99% of range

DRIFT

Gain - <±0.005% of full scale/°C
Zero - <±0.005% of full scale/°C
Long Term - <±0.01% of full scale/24 hrs. at a constant temperature

PEAK SHIFT - <±0.025% of full scale at rates to 50kHz.

FIXED DEAD TIME (FDT) - Dead Time enabled by an internal jumper and adjustable from ~13 to 45µsec. The FDT should be set to overlap the maximum normal Dead Time such that;
FDT ≥Linear Gate Time (max.) + 13µsec

AUTOMATIC RELEASE - Internal logic prevents system lockup; ADC is reset if converted data not accepted within ≈10msec.

POWER REQUIREMENT

105-125 or 210-250 VAC (Switch selectable)
50-400Hz
30 Watts

PHYSICAL

SIZE - Standard 19 inches rack mounted; 3.5 inches high by 18 inches deep (8.89 cm x 45.72 cm).

NET WEIGHT - 18 lbs. (8.2 kgs).

SHIPPING WEIGHT - 35 lbs. (15.8 kgs).

ACCESSORIES

Four (4) foot cable for connection to Canberra Memory Unit supplied with ADC.

OPTIONS

8080-01 Live time corrector wiring for use with 2013 amplifier.

Model 8200
Stabilizer

Features

- Conversion gain or zero intercept correction
- Up to 14 bit input from ADC (16,384 channels)
- No clock rate restriction

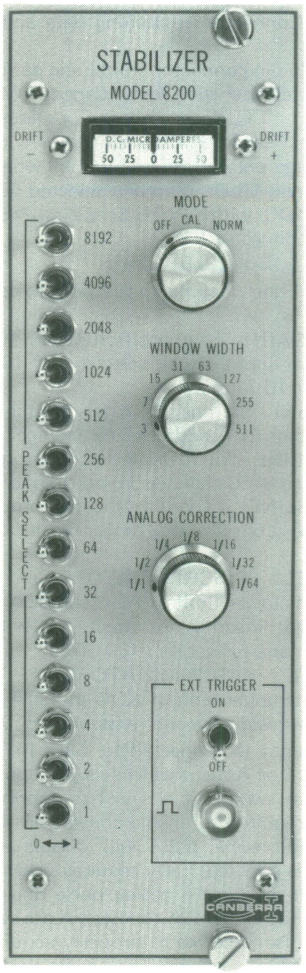
Description

The Model 8200 is used to maintain the stability of a nuclear spectrometer system in high resolution experiments of long duration. It accomplishes this by automatically correcting either the conversion gain or zero intercept of a binary analog-to-digital converter (ADC). Two Model 8200's can be used to correct both conversion gain and zero intercept simultaneously, if required. Error is detected by monitoring the ADC digital output, which reflects drift from all preceding system components. Consequently, all system drift can be compensated for by applying correction to the ADC only. The Model 8200 provides parallel entry of up to 14 bits (16,384 channels) from the ADC. Parallel entry enables operation with any binary ADC, since it eliminates the clock rate and pulse shape limitations of earlier serial entry stabilizers.

Unlike digital stabilizers that alternately add and subtract one count in a correction register when drift does not occur, the Model 8200 remains passive. Consequently, the analog correction output is not perturbed in any way when correction is not required.

Operation of the Model 8200 is the same for either conversion gain or zero intercept correction, except for the relative location of the reference channel selected. A high-numbered channel is selected for gain stabilization, since it will exhibit a more pronounced gain drift effect than a low-numbered channel. A low-numbered channel is selected for zero stabilization to minimize gain drift interaction. The stabilization reference channel is selected by means of binary switches. A stabilization "window", which is centered about the reference channel, can be varied from 3 to 511 channels in width. To facilitate set-up, all channels in the stabilization window can be intensified on the system cathode ray tube display when a "calibrate" mode is selected. Analog correction factor can be varied to compensate for expected or encountered drift of the system. Drift direction, magnitude, and rate of correction are indicated by a zero-center meter.

A front panel trigger input can be used to prevent memory storage of counts from a stabilization reference source, if desired. An analog recorder output on the rear panel enables drift monitoring over extended periods of time. The Model 8200 can also be used in conjunction with an ADC as a precise digital single channel analyzer with adjustable window width. It is housed in an AEC standard NIM configuration of two module widths.



Specifications

INPUTS

ADC OUTPUT - binary maximum of 14 bits parallel access; logic 1 = - 0.2V to +0.5V at 7.0mA; logic 0 = +2.0 to +5.0V at 1mA

ADC CONVERSION COMPLETE - logic 1 = - 0.2V to +0.4V at 1.5mA; logic 0 = +2.0V to +5.0V; minimum pulse width, 200ns., maximum rate, 250kHz

TRIGGER INPUT - logic 1 = +2.0V to +5.0V at 3mA; logic 0= - 0.2V to +0.4V at 1mA; minimum pulse width, 200ns., maximum rate, 250kHz; front panel BNC; pulse should be coincident with reference signal to ADC

OUTPUTS

CORRECTION SIGNAL - impedance 1k ohms; resolution, 1 part in 1024; Stability, equal to +12V NIM Bin Supply

Range:

1/1 - 5V to +5V
1/2 - 2.5V to +2.5V
1/4 - 1.25V to +1.25V
1/8 -.625V to +.625V
1/16 - 0.312V to +0.312V
1/32 - 0.156V to +0.156V
1/64 - 0.078V to +0.078V

RECORDER OUTPUT - impedance, 1K ohms; resolution, 1 part in 1024; stability equal to +12V NIM Bin Supply; range, - 5V to +5V

CONVERSION AT PEAK SIGNAL - logic 1 =0.0 to 0.4V at 5mA; logic 0 =+2.5V at 2.5mA; pulse width ≈500ns. (used for intensification or counting)

CONVERSION IN WINDOW SIGNAL - logic 1 = 0.0 to 0.4V at 5mA; pulse width ≈500ns. (used for intensification and Digital Single Channel)

INHIBIT ADD ONE - logic 1 = 0.0 to 0.4V at 5mA; logic 0 = +2.5V at 2.5mA

INTENSIFY - logic 1 = 0.0 to 0.4V

Specifications(continued)

OUTPUTS

LINEAR SIGNAL

Amplitude - 0 to 8 volts.

Polarity - positive.

Gain - 1 ±2%.

Integral Linearity - non-linearity is less than ±0.05% with >2μs rise time input pulse.

Stability

Gain - drift is less than 0.02% of full scale per degree Centigrade change from +10°C to +45°C.

Zero - drift is less than 0.02% of full scale per degree Centigrade change from +10°C to 45°C.

Long Term - drift is less than 0.01% of full scale over a 24-hour period at constant ambient temperature.

DATA - ADC data is directed through the Model 8220 to the Processor. The four most significant bits of this data are gated by the Model 8220 for memory group assignment. The bits are jumpered internally to correspond to the memory size used; normally set for 4K (12 bit) memory unless otherwise specified. The Model 8220A may be used with a 1K or 4K memory without jumper changes.

CONNECTORS

LINEAR SIGNAL AND COINCIDENCE INPUTS, LINEAR SIGNAL OUTPUT - BNC.

ADC INPUT - 25-pin Amphenol #17-10250. (8220 only).

ROUTER OUTPUT TO PROCESSOR - 25-pin Ampher #17-10250.

ROUTER BUS - 15-pin Amphenol #17-20150 (8220 only).

ROUTER BUS (REPEATER) - 15-pin Amphenol #17-20150 (82 only).

POWER REQUIREMENTS

+24VDC	—	5mA			
+12VDC	—	380mA	- 12VDC	—	36mA

PHYSICAL

SIZE - standard double-width NIM module (2.70 x 8.71 inches) TID-20893 (rev.).

NET WEIGHT - 4.5 lbs. (2.5 kgs).

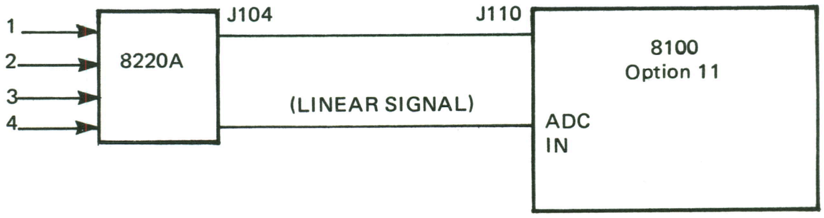
SHIPPING WEIGHT - 9.5 lbs. (4.28 kgs).

MODEL 8220A

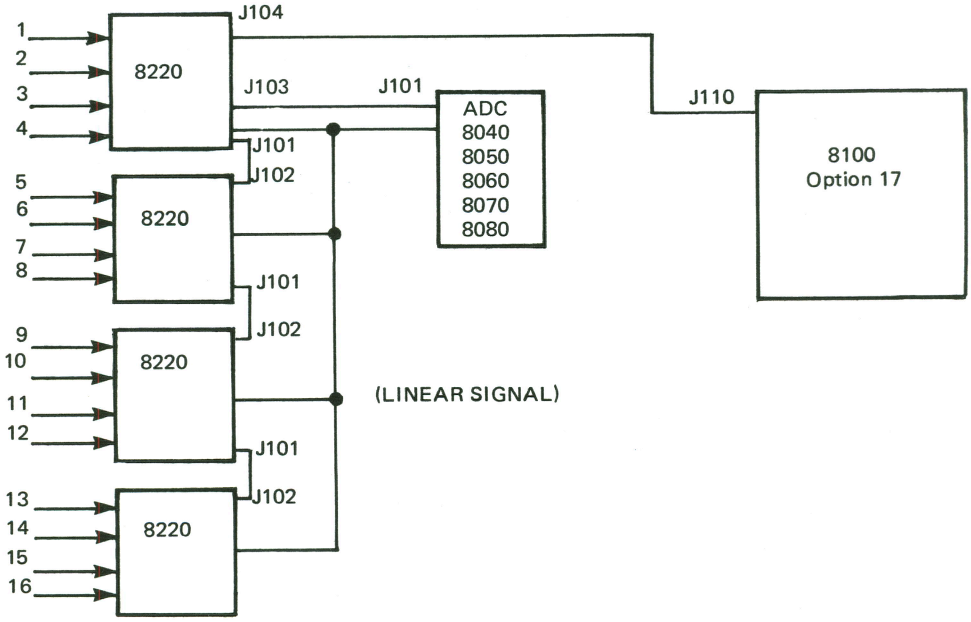
The Model 8220A Mixer/Router is used with Canberra MCA's a their internal ADC having the appropriate wiring option included the analyzer. The 8220A and MCA can accommodate a maximu of 4 inputs. Standard 8220's and an external ADC are required gating more than 4 inputs into the MCA.

Typical applications with the 8100 MCA are:

a. 4 or less Inputs


1
2
3
4
8220A
J104
J110
(LINEAR SIGNAL)
8100
Option 11
ADC
IN

b. More than 4 Inputs


1
2
3
4
8220
J104
J103
J101
J102
5
6
7
8
8220
J101
J102
9
10
11
12
8220
J101
J102
13
14
15
16
8220
J101
ADC
8040
8050
8060
8070
8080
J110
8100
Option 17
(LINEAR SIGNAL)

Model 8221
Multi Input Multiscaler

Features

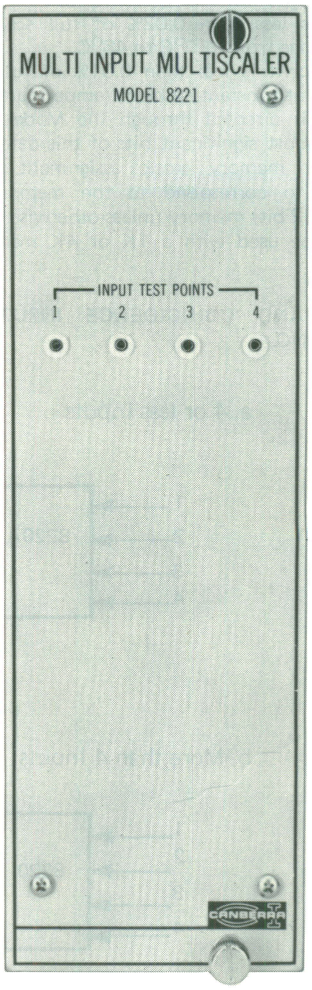
- 150kHz input rate
- Independent gating input

Description

The Model 8221 is a router module used for multiple input multiscale (MMCS) operation of the Multichannel Analyzer. When the Model 8221 is used with a Canberra Industries Multichannel Analyzer, Model 8100, it enables signals from up to four separate sources to be processed. A single gate input is provided to disable the inputs.

The Memory Control on the analyzer selects the number of inputs that are to be routed in its memory. With the control in the A/4 position, data acquired from each of the four inputs is automatically assigned to a separate quarter of the MCA memory. In the A/2 position inputs 1 and 2 will be routed and counted. In all other positions INPUT 1 will be counted into the full memory group selected.

The front panel Test Points allow for monitoring of the four input signals.



Specifications

INPUTS

NUMBER OF INPUTS - four

SIGNAL INPUT

PULSE REQUIREMENTS

Amplitude - +2.5 to +10 volts

Polarity - positive or bipolar; for bipolar signals, positive portion carries information

Width - 40 nanoseconds, minimum

Pulse Pair Resolution - 5 microseconds minimum for each input, with a combined input rate of 150kHz maximum for the number of active inputs. Single count buffers will store inputs received, while the memory is storing an earlier input on one of the other channels

GATE INPUT

SIGNAL REQUIREMENTS

TTL compatible input, negative logic 0 volts - true, minimum duration 30 nanoseconds

OUTPUTS

COUNT OUT

TTL output signal, positive logic - width 0.5μsec, synchronized with each signal input

CONNECTORS

SIGNAL INPUTS, GATE INPUT, AND SIGNAL OUTPUT - BNC's (rear panel)

MCA CONTROL TO MULTISCALER - 9-pin Amphenol #17-20090-1 (rear panel)

POWER REQUIREMENTS

115VAC — 125mA, 50-60Hz
+12VDC — 30mA
-12VDC — 20mA

PHYSICAL

SIZE - standard double-width NIM module (2.70 x 8.71 inches) (6.85 cm x 22.13 cm) per TID-20893 (rev.)

NET WEIGHT - 3.15 lbs. (1.43 kgs)

SHIPPING WEIGHT - 4.3 lbs. (1.94 kgs)

ACCESSORIES

One Canberra 9-pin, male to male, cable, 4 feet in length is supplied for connection to the MCA

Model 8241
ADC Time Base

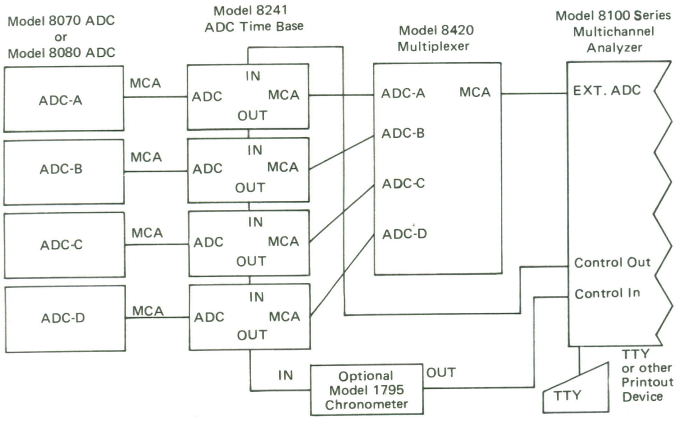
Features

- Live or True Time operation
- Manual or Automatic operation
- Preset time range of 1 second to 9 x 10^5 seconds of 0.1 minutes to 9 x 10^4 minutes
- Provides Automatic Time Base Identification via the Daisy Chain

Description

The Model 8241 provides a time preset and increment to channel zero when an ADC is used with Multiplexers or Computer Interfaces. The ADC Time Base, when used in conjunction with the Model 8420 ADC Multiplexer, allows multiple independent ADC's — each with its own time base and channel zero — to be used with the Model 8100 MCA. For fully independent operation each ADC requires its own Model 8241 Time Base.

Figure 1 illustrates a typical four-input system with each ADC operating independently with respect to time. In addition to providing the Time Base for each ADC in the system, the Model 8241 can also be used as the Data Acquisition Controller for the ADC. When the front panel MANUAL/AUTO switches are in the MANUAL position, placing the MCA in COLLECT merely enables the ADC's. It takes operator action (or logic signals via rear panel BNC's) to actually START or RESET the Time Base.

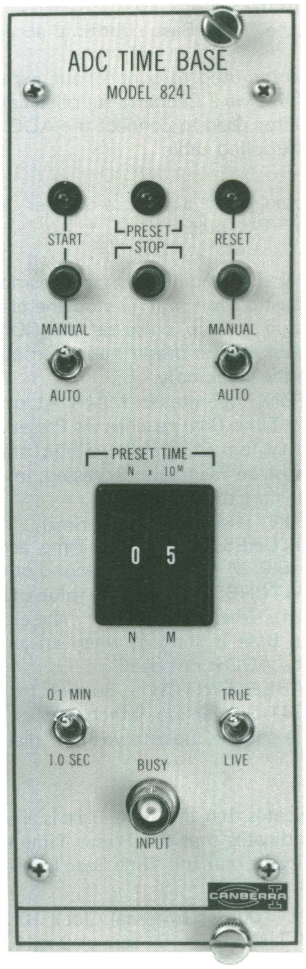


Model 8070 ADC
or
Model 8080 ADC
Model 8241
ADC Time Base
Model 8420
Multiplexer
Model 8100 Series
Multichannel
Analyzer
ADC-A
ADC-B
ADC-C
ADC-D
MCA
MCA
MCA
MCA
IN
ADC
MCA
OUT
IN
ADC
MCA
OUT
IN
ADC
MCA
OUT
IN
ADC
MCA
OUT
ADC-A
MCA
ADC-B
ADC-C
ADC-D
EXT. ADC
Control Out
Control In
IN
Optional
Model 1795
Chronometer
OUT
TTY
TTY
or other
Printout
Device

Figure 1. Typical Setup using the Model 6241 Time Base

Assuming use with the 8100/QUANTA Computer-based MCA System, the stopping of any Time Base (manually or by reaching preset) would cause the following sequence of events:

1. The MCA is stopped (via the Time Base) and a "Done" sent to the computer.
2. The computer initiates a readout to the MCA to read the Daisy Chain data - the first four data elements transmitted.
3. The Daisy Chain data are examined to determine which Time Base has stopped.
4. The appropriate memory region is read out and cleared.
5. The MCA, and all the other ADC's are restarted and resume operation after the temporary suspension



ADC TIME BASE
MODEL 8241
START
PRESET
STOP
RESET
MANUAL
AUTO
MANUAL
AUTO
PRESET TIME
N x 10^M
0 5
N M
0.1 MIN
1.0 SEC
TRUE
LIVE
BUSY
INPUT
CANBERRA

With this type of control sequence, four separate - and independent - ADC's can be easily controlled and processed.

A special 8241-DP version is offered which provides the capability to disable the MCA time channel update without disturbing the Daisy Chain time preset. Switch selectable, this added feature allows multiple ADC's to work in coincidence without asynchronous time interruptions while still providing a preset time capability. If a time base is required for ADC's in a dual parameter system employing a Model 8440A, the 8241-DP version must be specified.

Specifications

INPUTS

BUSY INPUT - if the unit is in Live Time, a signal at this input will gate off the Clock; a "0" (or open circuit) will not gate; "1" = 2.2 to 5 volts; "0" = 0 to 0.8 volts

SBSYA & SBSYB - will gate the Clock off when either input is "1"

CONTROL IN/OUT - provides Data Out to indicate whether or not the Model 8241 has reached Preset; at the Preset state the data read will be 000001; at all other times the data read will be 000000; this connector also provides a Stop signal to the MCA and receives Stop-Start-Reset from the MCA

START IN - starts the Time Base counting; accepts positive T^2L pulse

ADC - 25-pin connector used to connect the external ADC to the Time Base (Model 8241) via a Canberra-supplied cable

MCA - 25-pin connector used to connect the ADC Time Base to the MCA via a Canberra-supplied cable

OUTPUTS

PRESET OUT - used with a sample-changer interface; 50µsec nominal negative logic T^2L pulse

CONTROLS

STOP PUSHBUTTON - depending upon the position of the internal jumper, the STOP pushbutton will 1) stop the clock in the Model 8241 Time Base, issue a Stop pulse on the CONTROL IN/OUT connector and will look as if a preset has taken place in the Model 8241, or 2) will stop the clock only

START PUSHBUTTON - operates in MANUAL or AUTO mode: in MANUAL, when the Time Base reaches its Preset Count and stops the system, the next system Start pulse will not start the Time Base - the Start button must be manually depressed; in AUTO, any Start pulse at any time will start the Time Base

RESET PUSHBUTTON - used to reset the timer

PRESET TIME SWITCHES - sets Preset Time according to $(N \times 10^M)$ (X), where N = 0-9, M = 0-5, X = 1 second or 0.1 minute

0.1 MIN/1.0 SEC SWITCHES - determines value of X in Preset Time

TRUE/LIVE SWITCH - When set at TRUE, the clock will run at all times after the Time Base is started; when set at LIVE, the clock will run only when the ADC is not dead

TIME STORE/DISABLE SWITCH - Special front panel switch provided on the 8241-DP version which allows the operator to disable the MCA time channel update without disturbint the Daisy Chain time preset

INDICATORS

START LIGHT - indicates that the Time Base is enabled

PRESET LIGHT - indicates that the Preset Time has been reached

RESET LIGHT - indicates that the Time Base is reset to zero

PERFORMANCE

TIME RESOLUTION - 100nsec (internal Clock 10MHz)

MAXIMUM PRESET TIME - 9×10^5 sec, or 9×10^4 minutes

CHANNEL ZERO STORAGE - either 1 sec. or 0.1 minute resolution

CONNECTORS

BUSY INPUT - front panel, BNC UG-1094/U

START INPUT, SBSYA INPUT, SBSYB INPUT, PRESET OUTPUT - rear panel, BNC UG-1094/U

MCA - rear panel, 25-pin AMP 17-10250-1

ADC - rear panel, 25-pin, AMP 17-10250-1

CONTROL IN - rear panel, 15-pin AMP 17-10150-1

CONTROL OUT - rear panel, 15-pin AMP 17-20150-1

POWER

+24V — 0mA   - 24V — 0mA
+12V — 25mA   - 12V — 15mA
115VAC — 85mA

CABLE

6-foot, 25-pin cable for connecting Time Base to MCA or Multiplexer is provided

PHYSICAL

SIZE - standard AEC double-width NIM module (2.70 x 8.71 inches) (6.85 cm x 22.13 cm) per TID 20893 (rev.)

NET WEIGHT - 2.8 lbs. (1.3 kgs)

SHIPPING WEIGHT - 7.8 lbs. (3.5 kgs)

Specifications(continued)

CONTROLS

PEAK SELECTOR - fourteen (14) toggle switches 1 to 8192 in a binary sequence; able to select Peak Channel from 1 to 16,383

MODE- OFF - stabilizer disabled, Error Register held at zero; CALIBRATE - comparator circuits enabled; Error Register not changed or reset; NORMAL - Stabilizer enabled

WINDOW WIDTH - rotary switch selects widths of 3, 7, 15, 31, 63, 127, 255, or 511: the window is centered at the Peak selected

ANALOG CORRECTION - switch to select the size of the correction 1/1, 1/2, 1/4, 1/8, 1/16, 1/32, or 1/64; the switch attenuates the correction by the amount of the setting

EXTERNAL TRIGGER - toggle switch; in ON position, a trigger pulse is required to enable change in stabilizer correction signal

SENSE SWITCH - rear panel switch reverses sense of output correction signal; a drift causing Peak to move to a higher channel will:

1. in "+" position cause correction output to increase
2. in "-" position cause correction output to decrease

GAIN ZERO SWITCH - rear panel switch puts correction signal on pin 21 or pin 20 or J2 and J3

CONNECTORS

TRIGGER INPUT - BNC

ADC INPUT, ADC INPUT (REPEATER) - 25 pin Ampher #17-10250

FUNCTION - 15 pin Amphenol #17-10150

POWER - 42 pin Amphenol #202515-3

POWER

+24VDC	—	30mA	+12VDC	—	60mA
+ 6VDC	—	500mA	- 12VDC	—	30mA

PHYSICAL

SIZE - AEC standard double-width NIM module (2.70 x 8.714 inch (6.85 cm x 22.13 cm) per TID-20893 (rev).

NET WEIGHT - 5 lbs. (2.35 kg.)

SHIPPING WEIGHT - 10 lbs. (4.70 kg)

METER

Zero center indicates drift magnitude, direction, and rate corrections

Model 865

6V D.C. Power Suppl

Features

- Supplies 6VDC to standard NIM bins
- Delivers 2 amps at less than 5mV PP ripple

Description

The Model 8650 is a 6 volt, 2 amp regulated DC Power Supply designed to furnish 6 volts to a standard NIM bin. The 8650 occupies 2 NIM widths and operates to energize the positive or negative 6 volt busses when plugged into the NIM bin. It is factory shipped as a positive 6V supply.

For stabilized ADC applications, the 8650 is used to provide +6VDC to up to four Model 8200 Digital Stabilizers.

Specifications

INPUTS

AC POWER - 105 to 125VAC; 47 to 63Hz, Pins 33 and 41 on NIM power connector.

OUTPUT

+6VDC - 0 to 2 amps; positive to pin 10, negative to pin 34 on NIM power connector.

- 6VDC - 0 to 2 amps; negative to pin 11, positive to pin 34 on NIM power connector.

Output is internally adjustable and floating; factory set as a +6 volt supply.

FRONT PANEL CONTROLS

POWER - locking toggle switch for ON-OFF operation.

TEST TERMINAL - two test point jacks to monitor DC volta output.

FUSE - 0.5 amp Slo Blo in AC circuit.

INDICATOR - neon lamp to indicate AC power to regulator circu

INTERNAL CONTROLS

OUTPUT - single turn potentiometer varies DC output ±5%.

PERFORMANCE

REGULATION - ⩽±0.15% change in output voltage for line load changes within ratings of supply.

RIPPLE - ⩽1.5mV RMS; 5mV peak to peak.

OVERSHOOT - none for turn ON/OFF.

TEMPERATURE COEFF - ⩽±0.03%/°C, operating range 0 40°C.

PROTECTION - output protected to 3.2 amps.

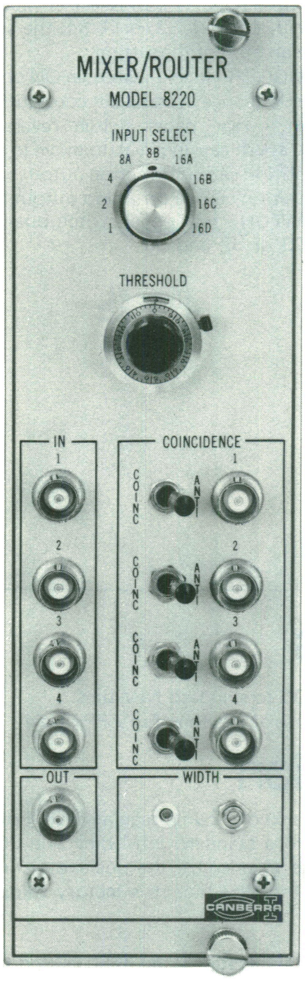
PHYSICAL

SIZE - standard double-width NIM module (2.70 x 8.71 inche (6.85 x 22.13 cm) per TID-20893 (rev.).

NET WEIGHT - 3 lbs. (1.4 kgs).

SHIPPING WEIGHT - 5 lbs. (2.3 kgs).

Mixer/Router Model 8220/8220A



Features

- Four linear gates service four inputs
- High degree of cross-talk rejection and freedom from signal distortion
- Four independent coincidence/anti-coincidence gating inputs

Description

The Model 8220 is a mixer/router module used for multiple input PHA operation of a multichannel analyzer system. When the Model 8220 is used with a Canberra Industries' analog-to-digital converter and digital processor, it enables signals from up to four separate sources to be processed on a first-come, first-served basis. Data acquired from each of the four inputs is automatically assigned to a separate quarter of the digital processor memory. If input signals appear at two or more inputs simultaneously, data storage is prevented. Up to four Model 8220's may be interconnected to provide first-come, first-served processing of signals from a maximum of 16 separate sources with one multichannel analyzer system.

Unlike conventional mixer/router systems that have one linear signal gate to service all four inputs, the Model 8220 has four, each servicing one input. During operation, the linear signal gates to all four inputs are blocked 500 nanoseconds after an input signal exceeds the trigger threshold for any one of the four inputs. Although the threshold level for all four inputs is established with a single front panel control, four separate trigger circuits are included. The trigger circuits serve the multiple function of providing signals for data routing, opening their associated linear gates, and providing signals for two-or-more coincidence sensing reject circuitry. The end results of the circuit techniques employed in the Model 8220 are an exceptional degree of cross-talk rejection and freedom from signal distortion.

The Model 8220 also includes four independent coincidence/anti-coincidence gating inputs. Either coincidence or anti-coincidence gating of each linear signal input can be selected by means of a front panel switch associated with each gating input. Analog sampling of AC or slowly varying DC wave forms can also be accomplished by periodic coincidence gating of the linear signal inputs.

Specifications

INPUTS

NUMBER OF INPUTS - four.

SIGNAL INPUT

Pulse Requirements

Amplitude - 0 to 8 volts.

Polarity - positive or bipolar; for bipolar signals, positive portion carries information.

Rise Time - 1 to 19μs as determined by linear gate aperture adjustment.

Slow AC and DC Signal Requirements

Amplitude - 0 to 8 volts, nominal.

Polarity - positive.

Gate Width - front panel adjustment of linear gate aperture time from 1.2 to 19μs with front panel inspection point.

Input Impedance - approximately 1000 ohms.

Coupling - direct (an external baseline restorer is required for high counting rates).

Internal Delay - 500 nanoseconds.

COINCIDENCE INPUT

Signal Requirements

Amplitude - 2.5 to 10 volts = true, 0 volts = false.

Polarity - positive.

Duration - 250 nanoseconds, minimum.

Gating Modes

Coincidence - gating signal enables processing of linear input signal.

Anticoincidence - gating signal prevents processing of linear input signal.

THRESHOLD CONTROL - minimum amplitude acceptance level for all four inputs is adjustable from 0 to 10% of full scale by means of a ten-turn lower-level discriminator control.

Model 8420
Multiplexer

Features

- Allows 1 to 4 independent ADC's to be used with 1 MCA
- Plug compatible with both 8700 and 8100/8180 MCA families
- Operates with any mix of 8040, 8060, 8070, or 8080 ADC's
- Switch selection of seven different storage modes
- Allows ADC's to use independent (Model 8421) time bases or the common MCA time base
- With four ADC's the ADC dead time is increased by only 1.5μsec
- Special 1.3MHz polling circuit prevents a high count rate input from locking out lower count rate inputs

Description

The Model 8420 ADC Multiplexer allows the user to expand a single-input MCA system into a multi-input system, greatly reducing the cost-per-detector for multichannel analysis. With the Model 8420, a maximum of four independent detector & ADC systems can share a single MCA processor.

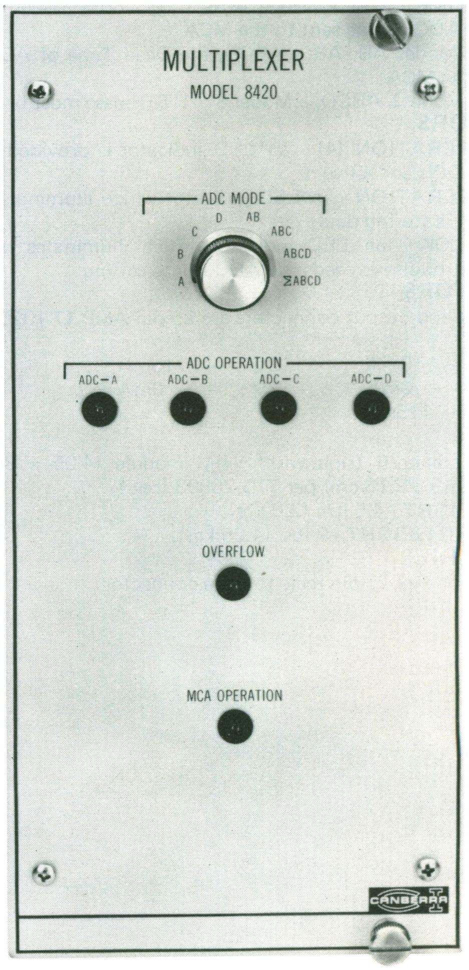
A front panel rotary switch allows the user to conveniently select the ADC's required for a given experiment. Indicator lamps (LED's) provide a visual check on ADC operation and count rate.

Internal jumpers provide for three modes (A, B, and C) of MCA memory allocation. These are summarized in the following tables:

MODE A - 1024 CH MCA ONLY				
	ADC			
Switch Pos.	A	B	C	D
A	1024			
B		1024		
C			1024	
D				1024
AB	512	512		
ABC	512	256	256	
ABCD	256	256	256	256
Σ ABCD	1024	1024	1024	1024

MODE B - 4096 CH MCA ONLY				
	ADC			
Switch Pos.	A	B	C	D
A	4096			
B		4096		
C			4096	
D				4096
AB	2048	2048		
ABC	2048	1024	1024	
ABCD	1024	1024	1024	1024
Σ ABCD	4096	4096	4096	4096

MODE C - 4096 CH MCA ONLY				
	ADC			
Switch Pos.	A	B	C	D
A	4096			
B		4096		
C			4096	
D				4096
AB	3072	1024		
ABC	3072	512	512	
ABCD	1024	1024	1024	1024
Σ ABCD	4096	4096	4096	4096



These tables illustrate several unique features of the Model 8420:

- **Σ ABCD OPERATION**

  This switch position causes all ADC's to share the same region of memory. By proper ADC and amplifier adjustment, tremendous efficiency increases can be affected, since up to 4 Ge(Li) detectors can be simultaneously used to analyze the same sample.

- **NON-SYMMETRIC STORAGE SHARING**

  In Mode C, switch positions AB and ABC allocate a full 3072 channels to ADC A, rather than only 2048. This allows the user to use a single 4096 MCA for both Ge(Li) and NaI without serious degradation of the system resolution for the Ge(Li).

The net effect of the Model 8420 Multiplexer, and its complementary 8241 Time Base is a very flexible multi-input system at a relatively low cost per detector.

Specifications

INPUTS

ADC (4) - accepts ADC output for steering into proper selection of MCA memory

OUTPUT

To MCA - provides data storage information to the MCA

CONTROLS

ADC MODE - selects the ADC's to be used. Refer to the previous tables for details on selection

DEAD TIME - in ADC Mode A, B, C, or D; the Dead Time of the selected ADC will be sent to the MCA

In ADC Modes AB, ABC, ABCD; the Dead Time of ADCA will be sent to the MCA

In ADC Mode Σ ABCD, a Model 8241 Timebase must be used.

INDICATORS

ADC OPERATION (4) - an LED indicator is provided to indicate which ADC's are active

MCA OPERATION - an LED indicator which illuminates whenever the MCA is storing data

OVERFLOW - an LED indicator which illuminates whenever an ADC input pulse exceeds the ADC Range setting

CONNECTORS

All input and output connectors are 25-pin AMP 17-10250-1

POWER

+24V	0mA	+12V	15mA
- 24V	0mA	- 12V	0mA

115VAC – 115mA

PHYSICAL

SIZE - standard triple-width NIM module (4.05 x 8.71 inches) (10.28 cm x 22.13 cm) per TID-20893 (rev.)

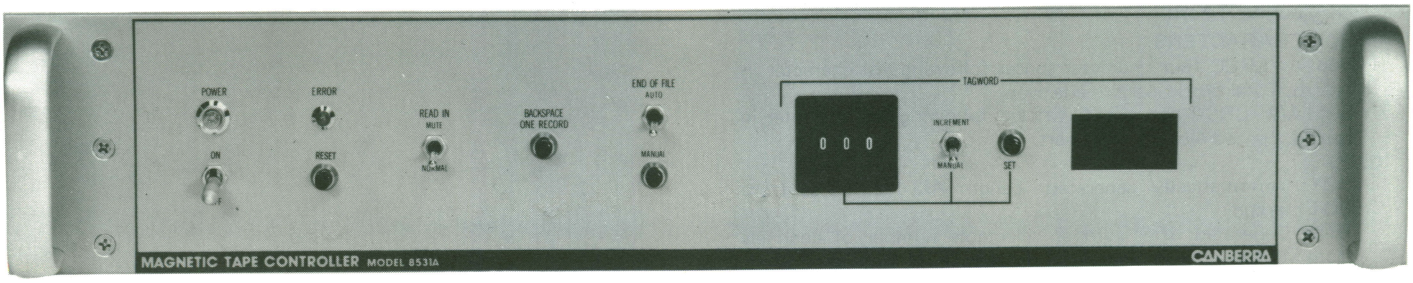
NET WEIGHT - 4.5 lbs. (2.0 kgs).

SHIPPING WEIGHT - 9 lbs. (4.05 kgs).

ACCESSORIES

One Amphenol 25-pin male to male connector

Model 8531A
Magnetic Tape Controller



Features

- 7 Track (Model 8531A) or 9 track (Model 8531A/9) operation
- Built-in 3 digit tagword for recording and searching
- Built-in 3 digit tagword increments for each read out
- Built-in LED tagword display for record and playback
- Automatic or manual EOF Generation
- Normal (data read-in) or mute (file search) playback modes
- Parity verification available during data record when used with a tape transport with read after write capability.

Description

The Model 8531A and 8531A/9 tape controllers provide high speed industry-compatible magnetic tape input and output for Canberra 8100/8180 Multichannel Analyzers. The Magnetic Tape Controller contains the necessary data formatting and transport control logic to couple the MCA to PERTEC magnetic tape transports.

The data format for the 7 Track (Model 8531A) controller is the standard industry compatible form of a 6 bit BCD character (plus a parity bit) for each frame of tape. Even parity is generated when recording and verified upon playback. An error indicator on the front panel is provided to indicate a parity error on playback. An appropriate LRCC is generated during recording. The data is recorded in NRZI with a density of 556 BPI and a tape speed of 25 ips.

The Model 8531A/9-track controller records one four bit BCD character per frame of tape. The high order 4 data bits of the frame are written as ones, and odd parity is generated. An appropriate CRCC and LRCC are generated. On playback individual frame parity is verified; the CRCC and LRCC are not. The data is recorded in NRZI with a density of 800 BPI and a tape speed of 25 ips.

For both the 7 and 9 track units, the required EOR and EOF gaps are generated. Depending upon the setting of a front panel switch, the EOF can be generated manually or automatically following each readout. The length of an individual record is determined via internal jumpers in the MCA.

When performing a MCA data readout a tagword is automatically written preceding the data. The front panel TAGWORD INCREMENT/MANUAL switch determines whether the tagword is equal to the TAGWORD thumbwheel switch settings or is the previous tagword incremented by one. A momentary TAGWORD set switch provides the ability to set the first tagword in a sequence of read outs as desired. On playback, the contents of the thumbwheel switches are used as a search word for use in locating the appropriate data. After the correct tagword has been found, the MUTE/NORMAL switch determines whether or not the data is to be transferred to the MCA.

As an additional aid, the controller contains on LED display which indicates the three least significant digits of the tagword. For Record, it displays the tagword last recorded. In Tagword Increment mode the display is one less than the tagword next to be placed on tape. For Playback, the display is that of the last tagword read, or during search, that of the tagword of the record being scanned.

For tape transports (PERTEC) with a read after write capability the controller will verify the parity of each character (byte) while data is being recorded.

Specifications

FRONT PANEL CONTROLS

POWER - switch (and Indicator) to supply line voltage to the power supply

ERROR - indicator lamp for:

1. Parity error during playback (during record with read after write capability transport.)
2. End of tape sensed
3. Attempt to record if no write enable ring

RESET - pushbutton switch to reset the error logic and indicator

READIN -

NORMAL: When the appropriate record is located, the data is transferred to the MCA

MUTE: When the appropriate record is found, the record is simply skipped over.

BACKSPACE - a pushbutton switch which causes the transport to backspace over one record; note that an EOF is logically a single character record

END OF FILE - in AUTO, an EOF gap and file mark are automatically written at the end of the data readout; this is not done in the off position

MANUAL - pushbutton switch to write an EOF gap and mark

TAGWORD -

THUMBWHEELS: Establish a 3 digit Tagword

INCREMENT/MANUAL: Toggle allows existing tagword to be incremented by one at the start of Record

SET: Momentary switch sets the desired first tagword (-1) in a sequence of readouts.

LED DISPLAYS: Indicates the 3 least significant digits of the tagword to be recorded or being read from the tape

Specifications(continued)

PERFORMANCE

TAPE DENSITY -

8531A (7 track): 556 char/in
8531A/9 (9 track): 800 char/in

TAPE SPEED - 25 i.p.s.

PARITY -

8531A (BDC): Even
8531A/9: Odd
Parity of data checked during playback or with Read After Write deck during Record.

CHECK CHARACTERS -

8531A: LRCC four character spaces following last character in record. Total bits in track made even.
8531A/9: CRCC and LRCC written following last character in record. Spaced 4 characters apart.

GAPS-

BOT: Automatically generated. Length ≈2-1/2 inches from BOT marker.
IRG: Generated after jumper selectable number of channels from MCA have been recorded. Length is >3/4 inch.
EOF: Generated manually or automatically. Includes File Mark and gap of >3-1/2 inches.
8531A: File mark is 1 written in tracks 4, 5, 6, 7.
8531A/9: File mark is 1 written in tracks 3, 6, 7.

CONVERSION OF BCD ZERO - for recording a BCD zero a 1 is written in tracks 4 and 6 (10). During Readin it is converted back to Zero.

REAR PANEL CONTROL

MCA - 2 position slide switch to select operation with the 8531A tagword or an externally generated word (e.g. 8700)

CONNECTORS

INPUT (J102) - from MCA; 50 pin Amphenol #17-10500-1; rear panel

OUTPUT (J103 & J104) - to tape deck; two 50 pin Amphenol # 17-10500-1; rear panel

CABLES

multiple connector cable to tape deck supplied

POWER

115 or 230VAC 50-400Hz, 35 watts

PHYSICAL

SIZE - Standard 19-inch rack mount 3-1/2 inches high by 18 inches deep (48.26 cm wide x 8.89 cm high x 45.72 cm deep)

NET WEIGHT - 15.5 lbs. (7.0 kgs)

SHIPPING WEIGHT - 22 lbs. (10.0 kgs).

SYSTEMS for RESEARCH and INDUSTRY 5

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D. Whole Body Counting Systems 290

E. Low Level Alpha Beta Counting Systems 296

F. Systems Software 301

NUCLEAR SYSTEMS INTRODUCTION

Over the past few years, Canberra's systems business has grown to a point where it constitutes a major portion of our business. We are now the largest and most diversified supplier of nuclear analysis systems in the world. We manufacture and sell products world wide for the Nuclear Research, Nuclear Fuel Cycle, Environmental, and Health Physics markets. As the leading company in this field, we know that we must keep our customers satisfied by providing the best equipment, the best applications support and the best after-the-sale service.

To be more effective in building, testing, and supporting complex systems we have created the Canberra Nuclear Systems Division. This new division will focus its effforts on the continued development of nuclear measuring systems. To meet this commitment, we have assembled a highly skilled staff of scientists, engineers, technicians and administrative personnel and located them in a modern 20,000 sq. ft. facility designed specifically for the manufacture of complex systems.

We are fortunate to start off with an excellent selection of products:

Radionuclide Analysis
- Jupiter Computer Network

Whole Body Counting
- Thyroid, organ and whole body burden analysis

Ultra Low Level Alpha/Beta Counting
- Manual and Automatic sample changer

Accountability and Safeguards Systems
- 55 gallon waste barrel analysis
- 5 gallon waste can analysis

Continuous Isotopic Monitoring Systems
- Liquid and gaseous effluent monitors
- Stack monitors

In today's world, technical obsolescence is rapid. With the development of new systems, many suppliers discontinue support of their older systems leaving their customers stranded. Consequently, many find it difficult to expand or add to their systems only one or two years after installation. Inherent in Canberra's systems design philosophy is a commitment to our present customers as well as our future systems users.

Our products are based on the philosophy that new product design must consider our current users as well as satisfying the requirements of new customers. By utilizing industry standard computer hardware and software operating systems, Canberra customers can incorporate our latest product developments into their existing systems.

Canberra's first computer based MCA system, which was introduced more than a decade ago, can be integrated, supported and used with our latest and most advanced JUPITER system. During this same time, some of our competitors have introduced several incompatible generations of equipment and software. Canberra's philosophy of dedication to our existing customers has withstood the test of time.

Today, Canberra's Radionuclide Analysis Systems are being used in numerous gamma spectroscopy applications throughout the world. They are being used in Universities, Hospitals, Government Institutions, Nuclear Power Plants, Fuel Fabrication and Reprocessing Facilities—in just about any facility where identification of a specific isotope is necessary.

In each case, the needs of the user are quite different, varying in degree of sophistication, capability and costs. To that end, Canberra offers a product line which encompasses the needs of the entire Radionuclide Analysis community. From our product line of Radionuclide Analysis systems, the user can select an economic configuration which meets his measurement requirements. The selection process begins with the correct detector and the appropriate Multichannel Analyzer. Next, we determine which of the many computers offered by DEC will satisfy the overall system requirement. Then, the language required for your task is selected. Much of the application software is available off the shelf from Canberra's software library. For the user who desires consultation, we have a team of specialists who will configure a system for you that will meet your requirements in the most cost effective manner.

Two tables are provided in this introduction which identifies some possible configurations for Radionuclide analysis. To help you understand the tables some definitions and explanations are included.

JUPITER

JUPITER offers a new concept in system design. It is a computer network that uses the Series 80 MCA or a Series 40 MCA as one of several possible nodes. Operating from stored instructions the Series 80 and the Series 40 have the ability to analyze spectral data. Connection to the host computer will permit the use of a more powerful processor for more sophisticated analysis.

The Series 80 node incorporates within it the latest thought in computer technology. Its triple processor, dual bus structure is designed to facilitate high input data rates, while providing an absolutely solid data display. In addition, the Series 80 itself has multi-tasking capability: up to 4 ADCs can be operated simultaneously and completely independently. Each Series 80 can accommodate 2K, 4K, 8K or 16K data channels capacity. Many satellite Series 80 nodes can be interfaced to the host computer from remote locations.

Two levels of performance are available in the computer for the Series-80 interface. The 8671 JUPITER Computer Interface is a moderate performance unit and is comparable to the computer interfaces of previous generations of Canberra multichannel analyzers. The 8671 model allows our current customers to upgrade to a Series-80 MCA without any change in their existing software. The high performance 8673 JUPITER Computer Interface operates at significantly faster transmission rates than the 8671 mode. This interface permits computer access to the extensive features of the Series-80 MCA.

The Series-40 MCA is a small MCA with big performance. It has a big memory (up to 8192 channels), a big ADC (100 MHz, 8192 channels), and a big display (9-inch raster scan CRT). For its performance, it is the smallest MCA in weight and size in its class. The 4273 Jupiter Computer Interface has the same high performance as the 8673 interface of the Series-80 MCA.

COMPUTER FAMILY

Canberra has designed all of its MCA products around the Digital Equipment Corporation's (DEC) PDP-11 family of computer systems. In addition, all of our application software is written using standard DEC operating systems. This allows our system user to expand or complement his system with industry standard hardware and software products.

The two standard software operating systems used by Canberra are DEC's RT-11 and RSX-11M.

REAL TIME OPERATING SYSTEM-RT-11

An operating system designed for interactive program development and for on-line applications on the PDP-11. RT-11 offers optimal support of a number of high-level language processors, including BASIC, FORTRAN IV and Canberra's own CLASS.

TIMESHARING-RT-11/TSX

This is a Canberra program written under RT-11. It is a Time Sharing Executive program which allows up to 8 users to time-share the background job facilities of RT-11. RT/TSX operates with a standard unmodified RT-11 foreground/background or single job monitor. Some Canberra RT-11 based application software will run under RT/TSX without modification. User application programs written for RT-11 can, in most cases, be run under RT/TSX without change.

In addition, numerous Series 80's and Series 40's can be intermixed in the system and run under RT/TSX.

MULTI-USER OPERATING SYSTEM RSX-11M

This is a real-time multiprogramming operating system that provides high-speed program execution running concurrently with multi-user program development. RSX-11M is compatible with all our MCA products. Likewise numerous Series 80's and Series 40's can be intermixed and run under RSX-11M. RSX-11M features disk-based operation, a comprehensive file system and event driven priority scheduling. Performance is maintained through dynamic memory allocation that includes automatic memory compaction, task check-pointing and provisions for both system and user controlled task partitions.

HIGH LEVEL LANGUAGES

FORTRAN—the PDP-11 FORTRAN IV is an extended superset of the American National Standards Institute (ANSI) FORTRAN, X3.9-1966 language. It is designed to minimize the size and increase the speed of the executable programs it produces, thus minimizing program development time. It operates under RSX-11M and RT-11 operating systems.

BASIC—is an interactive interpretive compiler operating under the RT-11 or RSX-11M operating systems. It is a high level conversational programming language; developed at Dartmough College, that uses simple English statements and familiar mathematical notations to perform an operation. Because of its conversational structure, BASIC is simple enough for the inexperienced programmer while having capability sufficient to control all of the system resources. Because of its simplicity, BASIC reduces programming time for developing applications programs.

CLASS—this is Canberra's own interpretive language, CLASS is as easy to use as BASIC, yet it has the computational powers of FORTRAN IV. Under RT-11, CLASS allows the user to add any DEC peripheral supported by RT-11 without modification to the software system.

APPLICATION SOFTWARE SPECTRAN III

A set of CLASS programs for use in performing sophisticated analysis of gamma-ray spectrographic data. Routines for performing complete qualitative and quantitative analysis of spectra obtained using Ge(Li) detectors, complete detector efficiency and energy calibrations, and various utility routines are included.

SPECTRAN F

A set of FORTRAN programs for use in performing sophisticated analysis of gamma-ray spectrographic data. SPECTRAN F employs the philosophy of SPECTRAN III with enhancements for faster, more efficient, and more accurate analysis.

BASIC/QUANTA

A set of BASIC programs for use in performing routine analysis of gamma-ray spectrographic data. Routines for performing energy calibration, peak locations and area computations are included.

ABACOS

A FORTRAN program for use in performing analysis of very low activity spectra obtained with NaI(Tl) detectors. ABACOS is designed specifically for use in organ burden and whole body counting. Routines for performing quantitative analysis, complete detector efficiency and energy calibrations and various utility routines are included.

GAMMA-M

This software package performs rapid and accurate analysis of gamma spectra obtained with sodium iodide (NaI) scintillation detectors. Routines are included for calibrating the system, searching for peaks, determining net areas, resolving multiplets, identifying nuclides, and calculating specific activities and minimum detectable activities. The analytical approach that was developed for the ABACOS Body Burden software is utilized in the GAMMA-M package. However, the nuclide libraries and input/output orientation is toward general laboratory spectroscopy, rather than toward a particular application. GAMMA-M is written in FORTRAN.

CANSCAN

A set of BASIC programs for use in analyzing low density waste containing ^{235}U and/or ^{239}Pu. Typical size waste containers are 55 gallon drums and 5 gallon cans. Routines provide quantitative analysis, correction for density variations and various utility routines.

ERGS

The Effluent Report Generation Software (ERGS) is a set of FORTRAN programs that produces reports for batch releases and continuous releases for both radioactive gaseous effluents and radioactive liquid effluents. The software is designed specifically for the needs of the nuclear power plant. It produces the monthly reports required by the plant management and the quarterly and semi-annual reports required by the U.S. Nuclear Regulatory Commission (per Regulatory Guide 1.21).

QA

The Quality Assurance (QA) software package provides the capability for performing a calibration check of germanium (both Ge(LI) and HpGe) detectors. The software produces a quality assurance report that gives current values, or current values and differences from reference values for: Germanium detector system gain shifts, germanium detector system resolution, and germanium detector efficiency.

JUPITER CONFIGURATIONS

Multichannel analyzer interface	RT-11 computer configurations	RT/TSX computer configurations	RSX-11M computer configurations
Series-80 MCA with 8673 interface, or Series-40 MCA with 4273 interface	11/03, 11/04, 11/23, 11/34, 11/44, 11/60	11/03, 11/04, 11/23, 11/34, 11/44, 11/60	11/23, 11/34, 11/44, 11/60, 11/70
Series-80 MCA with 8671 interface	PDT-11, 11/03, 11/04, 11/23, 11/34, 11/44, 11/60	11/03, 11/04, 11/23, 11/34, 11,44 /11/60	11/23, 11/34, 11/44, 11/60, 11/70

Table 1

APPLICATION SOFTWARE CONFIGURATION GUIDE

Software	MCA and Interface	Operating System
SPECTRAN-F	Series-80 with 8673 or 8671, Series-40 with 4273	RT-11, RT/TSX, RSX-11M
SPECTRAN-III	Series-80 with 8671	RT-11, RT/TSX
ABACOS	Series-80 with 8673 or 8671, Series-40 with 4273	RT-11, RSX-11M
CANSCAN	Series-80 with 8671	RT-11, RT/TSX
GAMMA-M	Series-80 with 8673 or 8671, Series-40 with 4273	RT-11, RT/TSX, RSX-11M
QA	Series-40 with 8673 or 8671, Series-40 with 4273	RT-11, RSX-11M
ERGS	Series-80 with 8673 or 8671, Series-40 with 4273	RT-11 RSX-11M

Table 2

JUPITER
Distributed Computer Network System

CANBERRA
COMPUTER SYSTEMS
CANBERRA

Features

- Multi-node computer networking
- Simultaneous acquisition and I/O
- Host computer - any Digital Equipment Corp. PDP-11
- Standard RT-11 or RSX-11M software operating system
- Radionuclide analysis software in Fortran IV or Canberra's own CLASS

Description

The JUPITER system features a totally new concept in design. It is a computer network that uses the Series 80 Distributed Processor MCA as one of several possible nodes operating from stored instruction and has the ability to analyze spectral data. Connection to the host computer will permit the use of a more powerful processor for more sophisticated analysis and a central data base system.

ARCHITECTURE

The Series 80 node incorporates within it the latest thought in computer technology. Its triple processor, dual bus structure is designed to facilitate high input data rates, while providing an absolute solid data display. In addition, the Series 80 has multitasking capability. Up to 4 ADC's can be operated simultaneously and completely independently.

Each Series 80 can accommodate 2K, 4K, 8K or 16K data channels. Satellite Series 80 nodes can be interfaced without burden to the host computer, enabling acquisition in up to 128K data channels.

APPLICATIONS

The JUPITER system can be tailored to a variety of applications in the nuclear community. Inherent in the design of the Series 80 node is a well though out modular front end. By choosing exactly the performance you need, you pay for only the performance you require.

General Spectroscopy

The Model 8621 is a general purpose front end module which offers a 100MHz ADC with an independent SCA. The 8621 provides a full 8192 channel gain and complete program control. Conversion gain, range and digital offset are fully programmable in the Series 80 node.

Physics Research

For research applications where the key signal processing criteria are versatility and flexability, the 8622 PHA/MCS front end is appropriate. The 8622 includes a built in high performance spectroscopy amplifier/baseline restorer which provides for excellent signal conditioning. The 8192 channel fully programmable 100MHz ADC ensures high resolution pulse height analysis.

The 8622 also provides excellent Multichannel Scaling (MCS) data acquisition via a 20MHz scaler input. Internal or external control, UP/UP or UP/DOWN sweep modes, DMA data storage — all the performance and features most experiments require.

Ge(Li) Spectroscopy

For high resolution Ge(Li) gamma spectroscopy a special high resolution spectroscopy amplifier is required. The Model 8623 is a high resolution spectroscopy amplifier with variable shaping time constants, active gated baseline restorer and a pulse pileup rejector/live time corrector.

Environmental Spectroscopy

With its built in Mixer/Router and 100MHz ADC, the Model 8624 ADC/MR is the optimum signal processing module for multi-input environmental spectroscopy. For Silicon Surface Barrier, NaI(TI) or Ge(Li) detector inputs, the 8624 can process them all simultaneously. Each of the 4 independent inputs has its own linear gate, live and true time clocks and a live time correction circuit. Each input can be individually started or stopped via the Series 80 Processor.

HOST PROCESSING

Host processing for a Series 80 node is straightforward and economical. Any Digital Equipment Corporation PDP-11 Series CPU can act as the host processor. The result – a JUPITER Computer Networking System. The JUPITER provides an optimum combination of centralized computing capabilities plus real-time, multi-task data acquisition and display. Whether you prefer a PDP-11/03 or a PDP-11/34 or even a PDP-11/70, the JUPITER performance levels are unsurpassed.

STANDARD OPERATING SYSTEMS

All JUPITER systems operate under DEC's powerful RT-11 and/or RSX-11M standard operating systems. As with the host processor, no single operating system can possibly meet every application need. With RT-11 or RSX-11M, the JUPITER can be tailored to meet any need without compromises and at any level of performance. The user can start out with RT-11 today and change over to RSX-11M in the future, and still use many of the same application programs. For the user who prefers RT-11, the Canberra RT/TSX time share executive program is an ideal extension. With RT/TSX, up to eight users can share the host computer with his own terminal and up to 8 Series 80 nodes . . . and only a PDP-11/03 CPU is required.

PRE-PROGRAMMED APPLICATIONS

The full capability of a system is only relevent if the results provide you with specific answers to specific problems. Here the JUPITER excels. Not only does the JUPITER provide the latest in intelligent computer networking, it provides the latest in algorithms for radionuclide analysis. For both Ge(Li) and NaI(TI) gamma spectra, JUPITER's application software provides state-of-the-art concepts in quantitative isotopic analysis, including advanced algorithms for multiplet resolution.

Whether you choose BASIC, FORTRAN or Canberra's own CLASS language, radionuclide spectral analysis is performed in a minimum of time. SPECTRAN III, a CLASS program for use in performing sophisticated analysis of gamma ray spectrographic data, utilizes special machine language spectrum analysis subroutines. Consequently, SPECTRAN III achieves an analysis speed approaching that of machine language-based systems with no sacrifice in flexibility. Time-consuming operations such as spectrum smoothing, differentiation and integration are performed in machine language. Logic decisions and report generation are performed in the CLASS language. This combination allows the user to custom-tailor the software to his particular needs without the tedium associated with machine language programming, and with no sacrifice in system performance.

SPECTRAN F is an enhanced FORTRAN version of SPECTRAN III. The FORTRAN version employs the philosophy of SPECTRAN III with enhancements for even faster and more efficient analysis. Routines are included for performing sophisticated, quantitative and quanlitative analysis of gamma ray spectrographic data using Ge(Li) detectors. Complete detector efficiency, energy calibrations and various utility routines are included.

SYSTEM CONFIGURATIONS

A typical JUPITER system consists of a Series 80 node, a host network interface, a host computer and a mass storage device. Additional computer peripherals, memory and Series 80 options can be added as dictated by the needs of a specific application. The diagram on the opposite page illustrates a typical JUPITER computer network.

To the left of the host-node interface is the Series 80 MCA. The Series 80 utilizes a distributed processor, dual bus architecture, which provides unmatched throughput without any compromise in performance.

Two independent tristate buses – each with a 660 nanosecond cycle time – provide an unmatched level of throughput capability. One bus is devoted to acquisition and display; the other to analysis I/O and host interfacing. The result is an optimum structure for efficient simultaneous operations.

The 3 independent LSI processors communicate directly with the tristate buses performing their dedicated tasks in a minimum of time and with great efficiency. The first processor is the Display and Acquisition processor. It is dedicated to data acquisition and spectrum display functions within the Series 80 node. The second processor is the Master Control processor. Its sole purpose is to provide guidance and real-time control of the Display and Acquisition processor. The third processor is a microprogrammed Bit Slice processor. The Bit Slice processor is dedicated to spectral display functions. Chores such as logrithmic and square root spectral display become simple and are executed in a minimum of time with the Bit Slice processor.

To the right of the network interface is the host computer system. The interface compliments the efficient architecture of the Series 80 node with its high speed transfer rate of up to 56K baud.

The host processor itself can be selected from any one of Digital Equipment Corporation's PDP-11 Series of CPU systems. DEC's extremely broad line of CPU's and peripherals enables the user to custom tailor a configuration to satisfy the performance requirements with equipment economy.

At any time in the future, the system can be upgraded to include additional Series 80 nodes, Model 8100 MCA's and additional computer peripherals.

TYPICAL JUPITER SYSTEM

Since numerous systems configurations are possible, a PDP-11/03 CPU configuration is illustrated with Ge(Li) detector input.

Model	**Description**
72XX	Ge(Li) detector specify: desired efficiency desired resolution
2001	Preamplifier
3105R	High voltage detector bias, 0-5kV.
8623	PHA/LTC. Spectroscopy amplifier, pulse pile-up rejector, live time corrector. 100MHz, 8192 channel ADC.
8603	Series 80 processor, 4196 channel
8684	I/O adaptor
8671	JUPITER computer networking interface.
5720	Host computer system, includes: PDP-11/03, 32Kb memory RX2VII dual drive high density floppy disk LA36 DECwriter H984 cabinet, DLVII, REVII
S210AAY	RT/JUPITER software package, includes: RT-11 V3B operating system RT/CLASS language processor JUPITER network commands SPECTRAN III radionuclide analysis software

PROGRAMMING LANGUAGE

As mentioned previously, all JUPITER systems operate under DEC's standard RT-11 or RSX-11M operating systems. To compliment the assembly language programming capability provided by either RT-11 or RSX-11M, the JUPITER system may include a standard high level programming language. Selection can be made from BASIC, Canberra's own CLASS or FORTRAN IV, depending on the user's familiarity or requirements. Any or all languages can be implemented on the same system simultaneously under RT-11.

BASIC

Standard versions of DEC BASIC are supplied for use with either RT-11 or RSX-11M operating systems. Both RT-11 and RSX-11M versions of BASIC are interactive interpretive compilers that allow highly efficient use of memory and other system resources.

CLASS

Canberra's own interpretive high level language developed specifically for laboratory data acquisition and analysis. It is as easy to use as BASIC, yet has the computational power of FORTRAN. CLASS is available with RT-11 only.

FORTRAN IV

FORTRAN is an extended superset of the ANSI (American National Standards Institute) Fortran IV language. It is available for use with RT-11 and RSX-11M.

GAMMA SPECTRUM ANALYSIS

In any computer-based analysis system, it is the application software that determines whether the system will provide satisfactory answers to specific problems. The JUPITER application software — SPECTRAN III provides accurate answers.

SPECTRAN III

SPECTRAN III is specifically designed to perform sophisticated analyses of gamma ray spectrographic data obtained with JUPITER computer-based data acquisition and analysis systems. SPECTRAN III is written in CLASS and includes programs that perform detector calibrations and complete qualitative and quantitative isotopic analysis. The data may be analyzed directly from the Series 80 node or from mass storage files.

The SPECTRAN III analysis package may be utilized in a wide variety of applications, including environmental, radiochemistry and health physics.

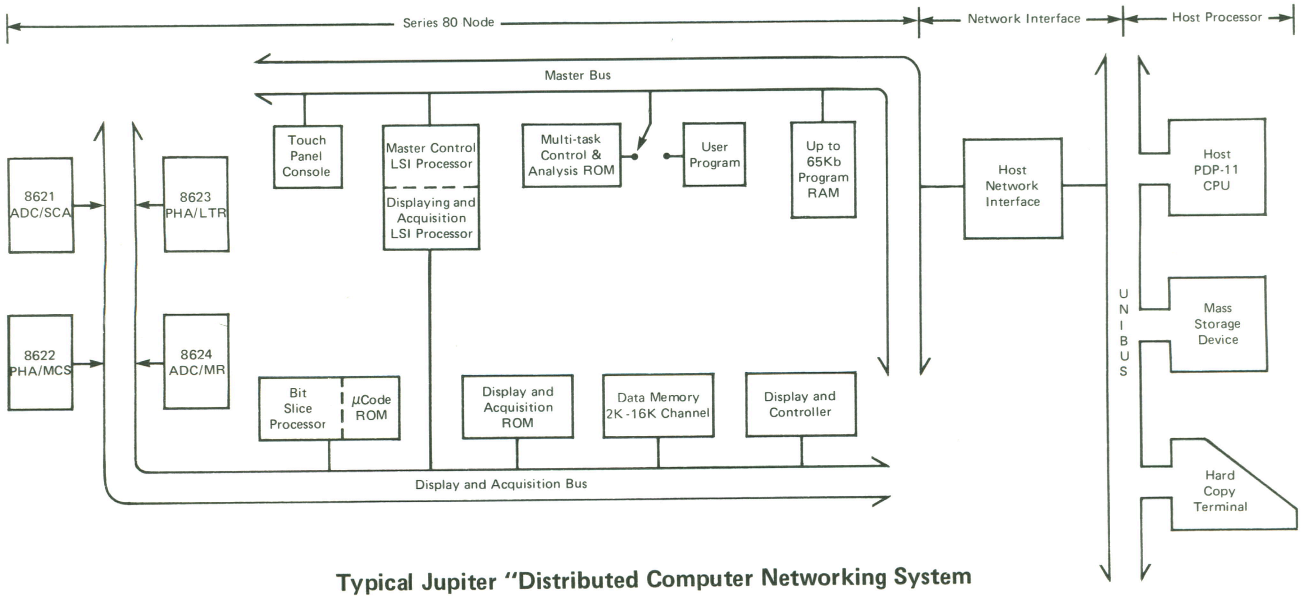
The first of the many programs which make up the SPECTRAN III package is CALIB, the system calibration routine. CALIB is used to perform energy resolution and efficiency calibrations for Ge(Li) spectrometer systems. Since more than one detector-amplifier combination and/or more than one Series 80 node may be used with a JUPITER system, up to 10 unique energy calibrations are allowed. Using a least-squares curve fitting technique, calibration equations are derived for the following:

- Second order relationships between energy and channel number.
- Second order relationships between detector FW.1M characteristics and channel number.
- Second order log-log relationships between absolute system efficiency and energy for multiple source-to-detector geometries.

In addition to printing out the calibration equations, CALIB also stores the calibration data on mass storage for later use by the analysis programs.

Once the system has been calibrated, any of the analytical programs may be run. Some available programs are:

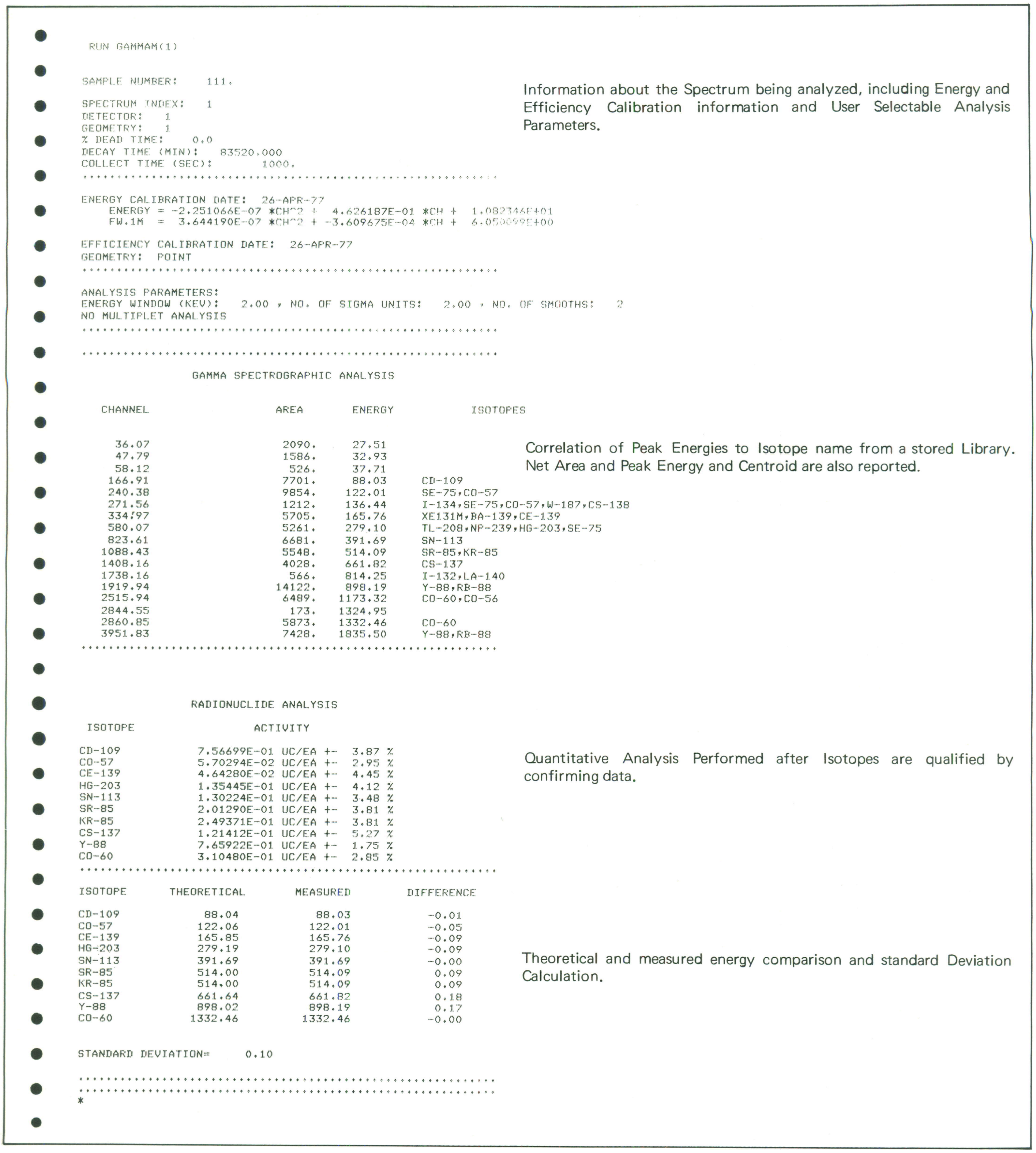
Program	**Function**
ANALYZ	Performs a quantitative analysis for up to ten user-specified isotopes.
GAMMA	Performs a peak search of the specified MCA memory region, reporting peak centroids (in keV and channel number), peak areas and statistical uncertainties.
GAMMAK	Conducts a peak search similar to GAMMA, but continues with qualitative and quantitative analyses. First, the peaks are listed, along with all isotopes with energy peaks that fall within a specified keV window of the peak centroid. Then, for all isotopes judged to be present (based on the presence of secondary peaks), the program computes microcuries per unit volume, along with statistical uncertainty.
MANDUB	Determines the areas the positions of unresolved multiplets that have been manually located in a spectrum.



Series 80 Node
Network Interface
Host Processor
Master Bus
8621 ADC/SCA
8623 PHA/LTR
8622 PHA/MCS
8624 ADC/MR
Touch Panel Console
Master Control LSI Processor
Displaying and Acquisition LSI Processor
Multi-task Control & Analysis ROM
User Program
Up to 65Kb Program RAM
Host Network Interface
Bit Slice Processor
μCode ROM
Display and Acquisition ROM
Data Memory 2K-16K Channel
Display and Controller
Display and Acquisition Bus
UNIBUS
Host PDP-11 CPU
Mass Storage Device
Hard Copy Terminal

Typical Jupiter "Distributed Computer Networking System

DATA ANALYSIS SHEET



```
 RUN GAMMAM(1)


SAMPLE NUMBER:    111.

SPECTRUM INDEX:   1
DETECTOR:   1
GEOMETRY:   1
% DEAD TIME:    0.0
DECAY TIME (MIN):   83520.000
COLLECT TIME (SEC):       1000.
............................................................

ENERGY CALIBRATION DATE:  26-APR-77
    ENERGY = -2.251066E-07 *CH^2 +  4.626187E-01 *CH +  1.082346E+01
    FW.1M  =  3.644190E-07 *CH^2 + -3.609675E-04 *CH +  6.050099E+00

EFFICIENCY CALIBRATION DATE:  26-APR-77
GEOMETRY:  POINT
............................................................

ANALYSIS PARAMETERS:
ENERGY WINDOW (KEV):   2.00 , NO. OF SIGMA UNITS:   2.00 , NO. OF SMOOTHS:   2
NO MULTIPLET ANALYSIS
............................................................
```

Information about the Spectrum being analyzed, including Energy and Efficiency Calibration information and User Selectable Analysis Parameters.

```
............................................................

                GAMMA SPECTROGRAPHIC ANALYSIS


   CHANNEL                  AREA       ENERGY          ISOTOPES


     36.07                  2090.       27.51
     47.79                  1586.       32.93
     58.12                   526.       37.71
    166.91                  7701.       88.03     CD-109
    240.38                  9854.      122.01     SE-75,CO-57
    271.56                  1212.      136.44     I-134,SE-75,CO-57,W-187,CS-138
    334.97                  5705.      165.76     XE131M,BA-139,CE-139
    580.07                  5261.      279.10     TL-208,NP-239,HG-203,SE-75
    823.61                  6681.      391.69     SN-113
   1088.43                  5548.      514.09     SR-85,KR-85
   1408.16                  4028.      661.82     CS-137
   1738.16                   566.      814.25     I-132,LA-140
   1919.94                 14122.      898.19     Y-88,RB-88
   2515.94                  6489.     1173.32     CO-60,CO-56
   2844.55                   173.     1324.95
   2860.85                  5873.     1332.46     CO-60
   3951.83                  7428.     1835.50     Y-88,RB-88
............................................................
```

Correlation of Peak Energies to Isotope name from a stored Library. Net Area and Peak Energy and Centroid are also reported.

```
                RADIONUCLIDE ANALYSIS

 ISOTOPE                ACTIVITY

CD-109          7.56699E-01 UC/EA +-  3.87 %
CO-57           5.70294E-02 UC/EA +-  2.95 %
CE-139          4.64280E-02 UC/EA +-  4.45 %
HG-203          1.35445E-01 UC/EA +-  4.12 %
SN-113          1.30224E-01 UC/EA +-  3.48 %
SR-85           2.01290E-01 UC/EA +-  3.81 %
KR-85           2.49371E-01 UC/EA +-  3.81 %
CS-137          1.21412E-01 UC/EA +-  5.27 %
Y-88            7.65922E-01 UC/EA +-  1.75 %
CO-60           3.10480E-01 UC/EA +-  2.85 %
............................................................
```

Quantitative Analysis Performed after Isotopes are qualified by confirming data.

```
ISOTOPE      THEORETICAL       MEASURED        DIFFERENCE

CD-109           88.04            88.03          -0.01
CO-57           122.06           122.01          -0.05
CE-139          165.85           165.76          -0.09
HG-203          279.19           279.10          -0.09
SN-113          391.69           391.69          -0.00
SR-85           514.00           514.09           0.09
KR-85           514.00           514.09           0.09
CS-137          661.64           661.82           0.18
Y-88            898.02           898.19           0.17
CO-60          1332.46          1332.46          -0.00

STANDARD DEVIATION=     0.10

............................................................
............................................................
*
```

Theoretical and measured energy comparison and standard Deviation Calculation.

ACCOUNTABILITY AND SAFEGUARDS SYSTEMS

In our expanding Nuclear Power Age, the problems of accountability and safeguards of fissionable material is becoming more critical. Canberra's commitment to the Total Fuel Cycle Market recognized the need for the detection and quantitative assay of fissionable materials. To that extent, Canberra, in 1973 built the first commercial Passive Gamma-Ray Waste Assay system. Since that time, Canberra has clearly established itself as the industry's leader in Waste Assay Systems.

Likewise, the need for quantitatively determining the isotopic content of radioactive releases from the stacks of nuclear power plants is critical. Again Canberra saw the need and developed the first commercial Ge(Li) detector stack monitoring system.

WASTE ASSAY

Canberra has developed three standard passive waste assay systems based on the requirement of United States Regulatory Guide 5.47 ''Control and Accountability of Plutonium in Waste Materials''. The systems are designed for assaying on a quantitative bases, low density waste containing Uranium and or Plutonium. The standard configurations will assay Hepa filters, 55 gallon drums, 5 gallon cans and 1 liter bottles.

Two basic techniques exist for measuring low density waste. They are neutron counting and gamma ray assay. The neutron technique has the following inherent disadvantages:

1. Neutrons are absorbed in low Z material.
2. Isotopic analysis cannot be performed.
3. Location of radioactivity in the waste container is difficult to determine.
4. Neutrons are absorbed in hydrogenous materials.

Consequently, to accurately determine the isotope quantitatively and the exact location in the waste container, the neutron counting technique is less than acceptable.

Numerous installations in the United States of the Canberra waste assay system have proved that the passive gamma ray technique is best suited to the task. Recently we have expanded our market to Europe and Asia with great success.

MODEL 2220B

The Model 2220B is designed to assay large Hepa filters, and containers ranging from 5 gallon cans to 55 gallon drums. Drums up to 400 lbs. can be accommodated. A complete assay for a 55 gallon drum requires about 15 minutes, including 5 to 7 minutes for loading and unloading a drum. Typical accuracy for a 10 minute scan is ⩽20%.

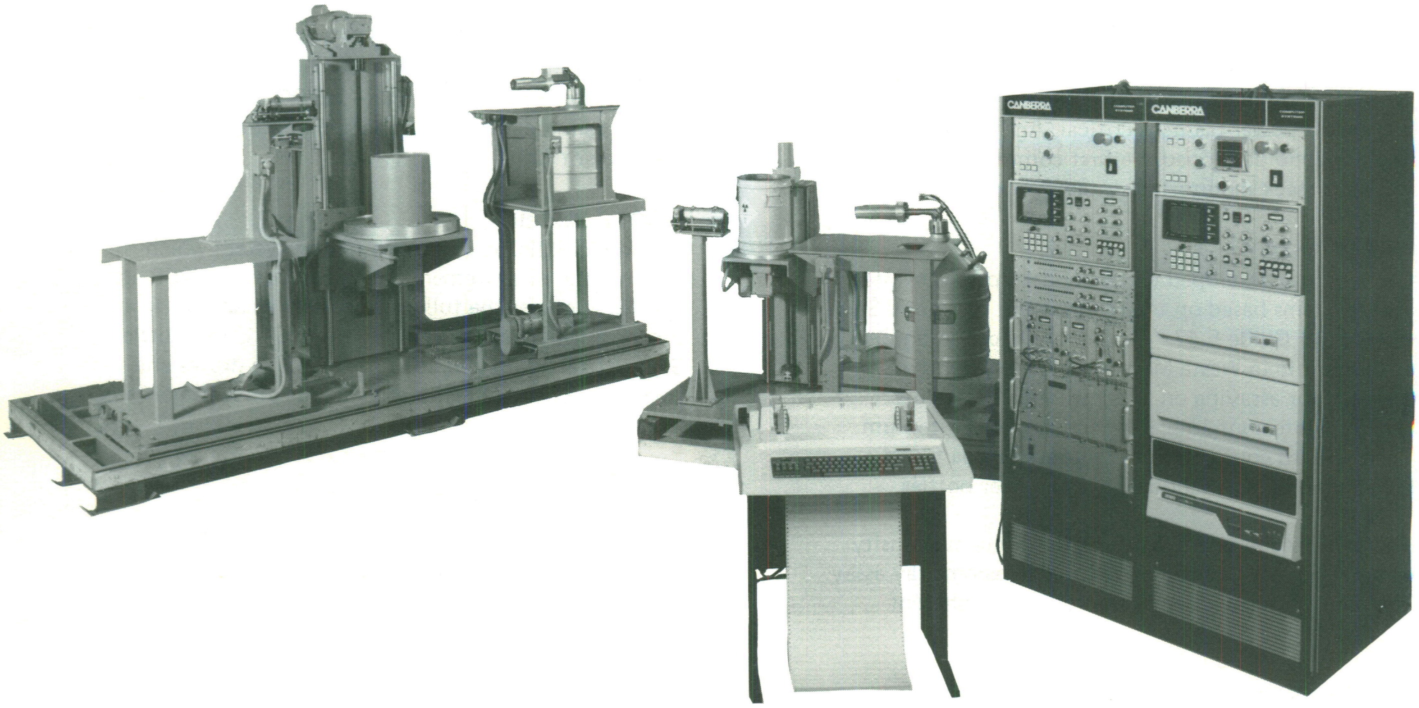
MODEL 2220C

The Model 2220C is designed to assay smaller containers ranging from 1 liter bottles to 5 gallon cans. Cans up to 80 lbs. can be measured by the 2220C. A complete assay for a 5 gallon can requires about 6 minutes for an accuracy of ⩽10%.

MODEL 2220BC

The Model 2220BC is a combination system which includes the measurement capability of the 2220B and 2220C. It covers the full range of container sizes from the large heavy drum down to the small 1 liter bottles. Separate tables are included for the large drums and small cans enabling faster throughput of waste containers.

Model 2220BC Segmented Gamma Scanner



Features

- Simultaneous analysis of ^{235}U and ^{239}Pu in large and small cans
- Automatic correction for matrix attenuation
- Rugged design for factory environments
- Pushbutton operation via control panel
- Complete assay for 55-gallon drums in less than 15 minutes
- Complete assay for 5 gallon cans in less than 6 minutes

Introduction

Radiometric non-destructive assay techniques developed by the Safeguard's Group at the Los Alamos Scientific Laboratory have been utilized by Canberra Industries in the development of Segmented Gamma Can Scanner Systems. The 2220BC was designed to assay both large and small containers for ^{235}U and for ^{239}Pu filled with low density waste such as rags, towels, rubber gloves and similar materials. Laboratory tests show that the 55 gallon scanner will measure 5 or more grams of ^{235}U or ^{239}Pu to an accuracy of ±20% while the 5 gallon can scanner will measure 1 or more grams to an accuracy of ±10%. A complete assay for 55 gallon drums requires about 15 minutes, including 8 to 10 minutes of counting time. For 5 gallon cans, assay time is approximately 6 minutes.

The entire system is completely automated and does not require a skilled operator. Selection of can size and assay routine is provided by front panel pushbuttons. By design, only the proper assay can be applied to the respective can size, thereby eliminating incorrect assays.

The system includes two Ge(Li) detectors, two multichannel analyzers, a dedicated mini-computer, and two rugged dual axis positioning systems. Control of the system is accomplished by the mini-computer (a Digital Equipment PDP-11)

The software, CANSCAN® is provided by Canberra Industries. Included with the software is a high level, conversational language which allows the operator to interact with the system, so that he can modify and tailor the system to his particular requirements. This interactive language capability provides unmatched flexibility to allow for possible changes in Regulatory requirements.

The dual table Segmented Gamma Can Scanner is made up of three sub-systems: An electronic sub-system, mechanical sub-system and detector sub-system. All operations for barrel and can scanning are provided to the operator from two control panels in the electronic sub-system, eliminating the need for operator interaction with the computer system. Once a can size and assay pass is selected, the system will perform automatically without operator intervention (with the exception of entering identification data).

Electronics Subsystem

Includes :

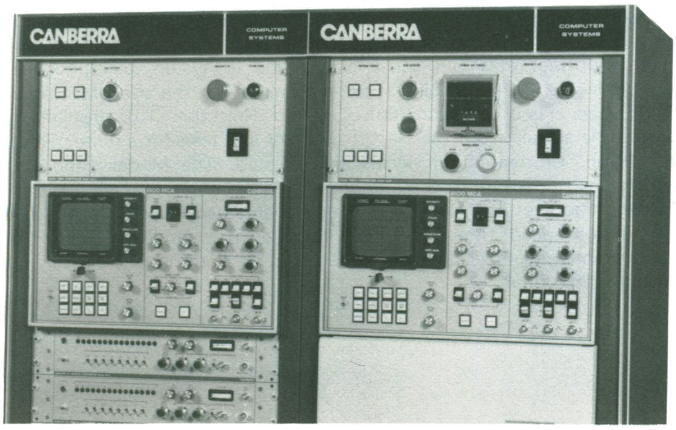
- Operator control panels with pushbutton operation of assay functions such as:
  - Initialization
  - Calibration
  - Assay
  - Abort
  - Source shutter operational check
- Hardwired Multichannel Analyzers
- Dedicated Minicomputer
- NIM stepping motor electronics

The electronics sub-system consists of four components, namely two operator control panels, hardwired multichannel analyzers, dedicated mini computer and standard NIM electronics. The control panels are used to initiate both the automatic and manual functions for its specific table. The panels were designed to keep the routine assay operations as simple as possible. The operator is not required to operate the computer for system operation.

The control panels are depicted in the figure below as the uppermost component in each cabinet. The control panel on the left is for the small table and the panel on the right for the large table. Additional operations available from the control panels are manual motion control, segment size selection (large table only), and EMERGENCY system off.

Stepping motor control is achieved through Canberra's Data NIM Automatiion electronics. The Data NIM modules are housed in Canberra's standard Model 6000 NIM bins, and are compatable with the Digital Equipment PDP-11 family of computers.

A Canberra QUANTA or JUPITER computer-based multichannel analysis system is integrated to the control panels. Scores of installations have proven the QUANTA or JUPITER approach to be a reliable, accurate means of on-line analysis of gamma spectra. The multichannel analyzer, at the flick of a switch, can be operated independently from the computer to collect a gamma spectrum of interest. Similarly, simple commands from the computer can initiate multichannel analysis independent of segmented scanner operation. A high level, conversational language (BASIC) is employed (rather than machine language) to allow the user at any time to alter the application software supplied to suit his specific needs.



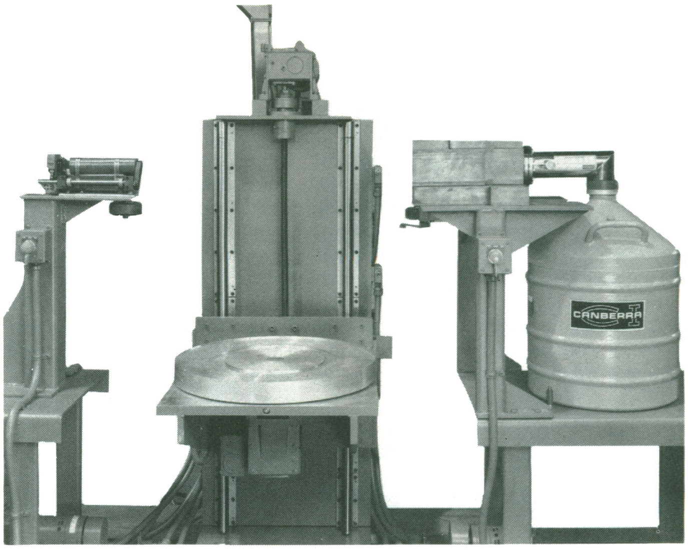
Mechanical Subsystem

Includes :

55 Gallon Drum system includes:

- Fail safe shutter control
- Accommodates 5 to 55 gallon drums
- Adjustable slip-clutch overload protection
- Anti-crash feature for damaged or bent barrels
- Rugged construction for heavy use.
- Supports 500 lbs. of lead bricks for detector collimation

The Model 2220B Barrel handler is designed to accommodate barrel sizes ranging from 5 gallons up to 55 gallons. Both the detector and the transmission source are mounted on motor-driven platforms to accommodate the loading and unloading of heavy barrels. The system includes four motors: one for vertical motion, one for table rotation, one for detector positioning, and one for transmission source positioning. All motor motion can be controlled manually or automatically via the assay software program. A shutter assembly is provided to cover the transmission source when it is not in use. The fail safe design of the shutter ensures that the transmission source will be covered when the system power is off. The shutter can be manually operated from the control panel, and of course, by the assay program.

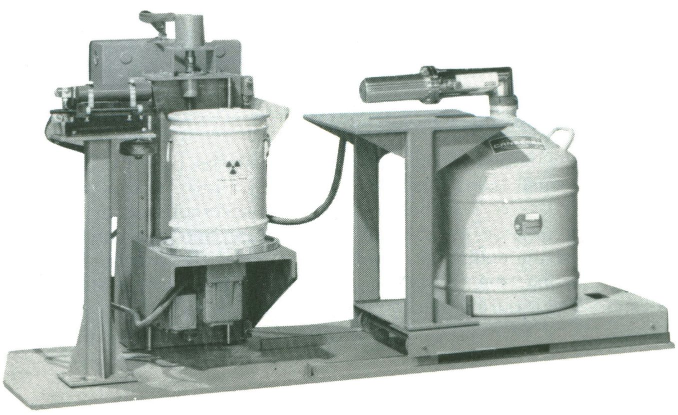


5 Gallon Can system includes:

- Precision stepping motor control
- Accommodates 5 gallon and smaller cans
- Fail safe shutter control
- Continuous or discrete segment scans
- Supports 500 lbs. of lead bricks for detector collimation
- Rugged construction for heavy use

The Model 2220C can handler is designed to accommodate cans ranging in size from 5 gallons down to any practical size container. A precision stepping motor is used to control the vertical axis to insure accurate positioning for maximum assay results. Continuous or discrete segment scans are coordinated with the vertical stepping motor and the multichannel analyzer. In the continuous mode, the multichannel analyzer dead time controls the scan speed. This feature insures equal live time weighting to all segments regardless of count rate.

The system includes two motors: A stepping motor for vertical motion and an AC motor for platform rotation. All motor motion can be controlled manually from the control panel or automatically via the assay software program.



Detector Subsystem

Includes :

Two identical detectors are supplied with the following features:

- Resolution and efficiency optimized for ^{235}U and ^{239}Pu analysis
- Designed to operate at 99% humidity
- Refilling of LN$_2$ with detector in place
- Ultra-high vacuum metal to metal seals
- Ceramic electric feedthrough
- Extra long cryostat and end cap for good collimation with standard lead bricks

The Ge(Li) detector is one of the most important items of the segmented scanner system, consequently, its resolution and efficiency have been selected for maximum performance at the energies of ^{235}U and ^{239}Pu. Since operation of a segmented scanner is generally not in a laboratory environment, the detector system has been designed to operate in factory environments. A unique design permits operation at 99% humidity conditions. Similarly, the cryostat and end cap are designed to allow collimation with standard size lead bricks. In this manner, the customer can conveniently change collimation size and build the shielding easily by placing the bricks around the end cap and the preamp. Refilling the detector with LN$_2$ does not require removal of the collimator or detector from its position.

By having two identical support geometries on the tables, either detector can be used with either table. This feature permits operation of either table if only one detector is available.

Technical Discussion

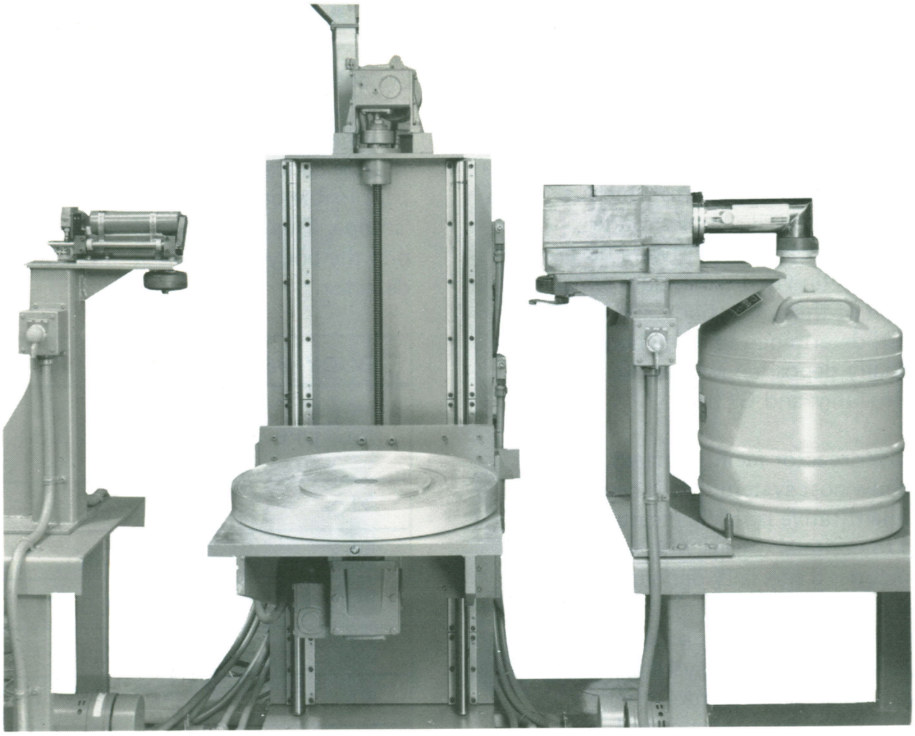
Because of the inhomogeneity of the waste material, both the 55-gallon barrel and small can must be segmented into horizontal slices approximately 1 to 3 inches thick. This is accomplished by using a horizontal collimator in front of the detector and by scanning the container past the collimater. Radial inhomogeneities are compensated for by rotating the container on a turntable such that several revolutions occur during one counting interval.

The 186keV gamma ray activity in a uniform sample containing dispersed Uranium in a low density matrix is proportional to the amount of ^{235}U present. The 414keV gamma ray activity is proportional to the ^{239}Pu present. The assay of ^{235}U or ^{239}Pu is complicated in practice by attenuation and absorption in the sample to be measured. Consequently, corrections must be made by measuring the transmission through each segment using a gamma ray of similar energy. For ^{235}U assay, the transmission source should emit gamma rays closely bracketing the 186keV ^{235}U peak, because mass attenuation coefficients in this energy region vary rapidly with energy. The transmission source used for ^{235}U assay is ^{169}Yb which emits a 177keV and a 198keV gamma ray. The attenuation of the 186keV gamma ray can be determined from a weighted average of the measured transmission of the 177keV and the 198keV gamma rays. For ^{239}Pu assay, a single transmitted gamma ray energy will suffice, because mass attenuation varies less for gamma rays in this energy region. The 400keV gamma ray of ^{75}Se is used for the ^{239}Pu assay.

It is important to recognize that a Ge(Li) detector is essential in this application. When using an NaI detector, there is a very high background at 186keV associated with interference counts from adjacent peaks in the spectrum due to the poor resolution of the detector. Moreover, this background changes as a function of the age of the ^{235}U. The half life of Thorium is only 24 days, therefore, the background from Protactinium is not stable for several months after enrichment. Using a Ge(Li) detector, spectrum resolution is good enough to practically eliminate this interference problem. When analyzing more complex spectra such as fuels from Plutonium, or a mixed fuel combination, the high resolution Ge(Li) is absolutely essential to resolve the signature gamma rays.

In the scanner's multichannel analyzer, regions-of-interest are defined for the various gamma rays of interest. To correct for source decay, transmission of the ^{169}Yb and the ^{75}Se gamma rays is first measured with no drum on the scanner. This measurement is usually made once a day. Drums are routinely scanned once to make the ^{235}U and the ^{239}Pu measurements. When the scan is complete, a background subtraction is performed on each peak. Drum transmission for each segment is calculated for 186keV and 414keV gamma rays; correction factors are applied for drum and content densities.

High counting rates (greater than 10,000 counts per second) will occur if the system is used in a high background area, if the system is measuring large quantities of fissile materials, or when scanning drums containing significant quantities of other radioactive materials. These high counting rates can cause errors due to system deadtime and pulse-pile-up. These problems are minimized by the use of a Model 1468 Live Time Corrector/Pulse Pile-up Rejector. This instrument senses the signals from the Ge(Li) detector and tests for a pulse pile-up condition. Contaminated signals are rejected. The Model 1468 also senses dead time due to the amplifier and pile-up rejector gate. It then corrects the live time clock in the multichannel analyzer to ensure that the system dead time correction includes not only the ADC and multichannel analyzer dead time, but also the amplifier and the pile-up rejector dead time.



Operation

The block diagram above illustrates the system. For automatic operation, the operator communicates with the pushbuttons on the Models 2225B and 2225C. After that, all control and table selection is done automatically by the hardware and software components. The Model 2225 assures that the assay selection is applied to the correct barrel or can handler system.

The software operation is performed by CANSCAN, ® Canberra's application software. CANSCAN is written in the BASIC language which provides the user with a powerful yet flexible software package. The latest version of CANSCAN has been designed to operate under Digital Equipment Corporations RT-11 Real time operating system. RT/TSX, Canberra's time share executive enables simultaneous operation of both tables.

CANSCAN consists of three major routines:

Calibration

The calibration routine is initiated by depressing the CALIBration button on the control panel. As described in the technical discussion, we will correct our measurement of the assay peak by measuring the density of the barrel. The calibration routine will enable the system to measure ^{235}U or ^{239}Pu. Each of the assay peaks can have at least one, but not more than two, transmission peaks associated with it. The manner in which these assignments are made is as follows:

1. The program asks the user to specify calibration parameters and to begin collection of a spectrum.
2. The system will automatically calculate the appropriate data and store the information internally.
3. Standards are then measured and conversion factors in counts/gram/second are calculated and stored.

NOTE: To improve the quality of measurement, the calibration measurement may be made in two passes. The first pass measures the assay peaks and the second pass measures the transmission peaks.

Initialization

The initialization routine is started by depressing the INITialization on the control panel. This routine allows the user to enter new calibration data without performing any measurements. A full list of all calibration data is printed out after each run of CALIBration, thus calibration data for various size containers may be saved and reloaded when changing barrel sizes.

Assay Program

Once the scanner is set up, a sample is assayed by placing it on the turntable with a forklift truck and calling an operating program. Certain clerical information is entered, including sample identification number, operator identification number, and data. The program allows the choice of either a single-pass (transmission source and sample counted simultaneously) or a two-pass (sample and transmission source counted on different scans). The two-pass scan eliminates transmission source interference on sample activity peaks.

The scanner collects and analyzes the data automatically and prints out the fissile material content of each segment and of the entire drum, along with the estimated uncertainty in the measurement. Drum segments with densities greater than 0.6/cm^3 (as measured with the transmission source) are identified and excluded from the analysis.

Specifications

55 gallon drum system

1. Accuracy ±20% for ^{235}U for densities up to 0.2gm/cm^3
2. Accuracy ±20% for ^{239}Pu for densities up to 0.5gm/cm^3
3. The system can calculate only the uncertainty due to counting statistics since the material is unknown.
4. Scan time for a 55-gallon drum $\leqslant$10 minutes.

5 gallon can system

1. Accuracy ±10% for ^{235}U for densities up to 0.2gm/cm^3
2. Accuracy ±10% for ^{239}Pu for densities up to 0.5gm/cm^3
3. The system can calculate only the uncertainty due to counting statistics since the material is unknown.
4. Scan time for a 5 gallon drum $\leqslant$6 minutes.

There are several sources of possible error which we attempt to minimize:

a. Contamination with an unknown radionuclide
b. Non-uniform dispersion of the material
c. System calibration accuracy depends upon the precision of standards used.

WHOLE BODY COUNTING SYSTEMS INTRODUCTION

For the protection of radiation workers, it is essential that an internal dosimetry program to detect mixed fission and activation products be utilized in nuclear power reactor facilities. Common measurement techniques include indirect bioassay programs which require the analysis of urine and fecal samples. State-of-the-art developments in hardware and software have made possible direct bioassay (in-vivo) techniques which enable direct measurement of the whole body and its critical organs. It has been determined that the body's critical organs (for internally deposited radioactive materials) are the thyroid, lungs and GI tract.

To fulfill the nuclear power reactor facilities needs, Canberra has designed a low cost system that is capable of quickly performing quantitative isotopic measurements for the whole body and the critical organs with high accuracy. The system includes a specially designed shielded chair with a geometry optimized for low background and detector efficiency, linear processing electronics, and a multichannel analyzing system. The chair is equipped with two NaI detectors; one detector for the thyroid and one for the lungs and central internal tract.

Canberra provides a variety of system hardware configurations to satisfy the varying needs of different power plants. The system might consist of our Quanta, Scorpio or Jupiter computer-based multichannel analyzers and may include one of Digital Equipment's PDP-11 family of computer's to provide a single dedicated system, a multi-user or time shared capability.

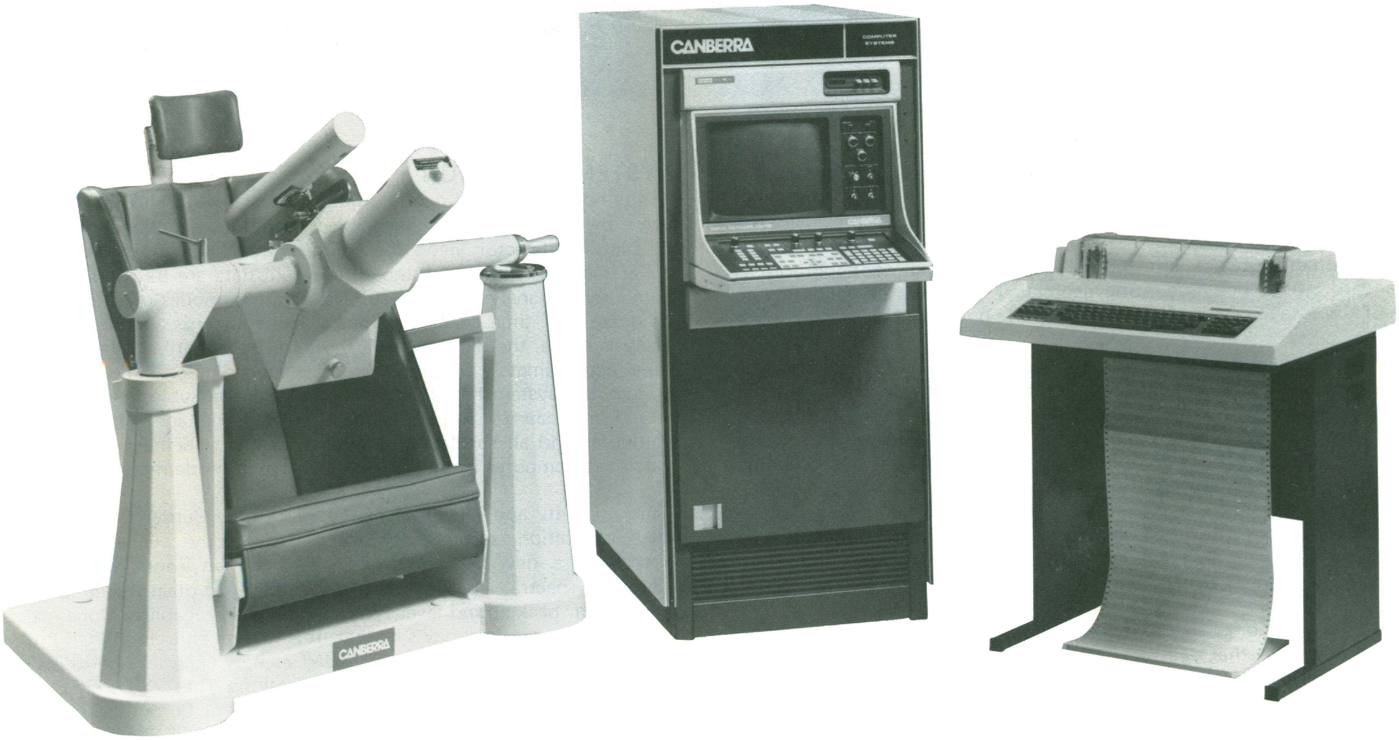
Canberra offers a variety of financing plans for these systems including rentals, three or five year lease plans or purchases.

A Canberra system is designed to provide a rapid screen for power plant personnel. The chart below indicates required measuring time to determine with 95% confidence concentration equivalent to 5%, the maximum permissible organ burden (MPOB) for each specific isotope. This is accomplished using two separate detectors: the body detector for lung burden and a thyroid detector.

BODY DETECTOR (Lung Burden)

ISOTOPE	MPOB (μCi)	TIME TO 5% MPOB
^{51}Cr	60	
^{54}Mn	3.65	
^{58}Co	2.9	
^{59}Fe	2.0	
^{60}Co	1.17	
^{65}Zn	5.6	
^{95}Zr - Nb	0.95	
^{103}Ru - Rh	3.11	
^{106}Ru - Rh	0.6	
^{124}Sb	0.913	
^{134}Cs	1.47	
^{137}Cs	2.05	
^{140}La	0.6	
^{144}Ce - Pr	0.65	
THYROID DETECTOR		
^{131}I		

Model 2230
Body Burden Analysis System



Features

- Accurate measurements of the whole body and the critical body organs
- Combines accuracy and ease of measurement of invivo radionuclide assay with equipment economy
- Allows measurements without extensive preparation
- Excludes head and extremities from detector field of view to eliminate false contributions from external contamination
- Includes a calibration service for
    - Whole body
    - Lungs
    - Thyroid
- State of the art software specifically designed for low level activity NaI(TI) Spectra, written in FORTRAN IV

Introduction

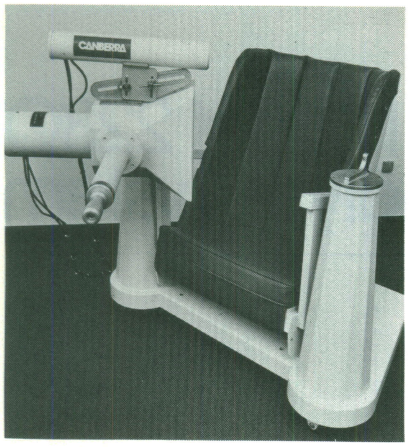
For the protection of radiation workers, it is essential that an Internal Dosimetry program to detect mixed fission and activation products be utilized in Nuclear Power Reactor Facilities. Common measurement techniques include indirect bioassay programs which require the analysis of urine and fecal samples. State of the art developments in hardware and software have made possible direct bioassay (in-vivo) techniques which enable instrumentation to directly measure the whole body and its' critical organs. It has been determined that the body's critical organs (due to internally deposited radioactive materials) are the thyroid, lungs and Gastro-Intestinal (GI) tract.

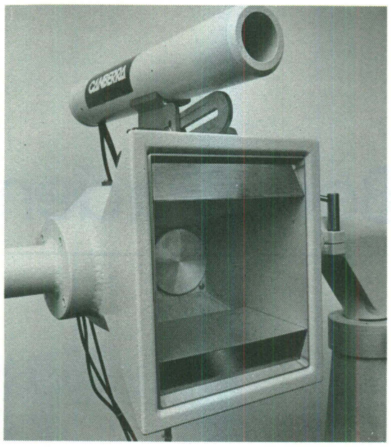
To fulfill the Nuclear Power Reactor Facilities needs, Canberra has designed a low cost system that is capable of quickly performing quantitative isotopic measurements for the whole body and the critical organs with high accuracy. The system includes a specially designed shielded chair with an optimized geometry for low background and detector efficiency, stable linear processing electronics, and a multichannel analyzing system.

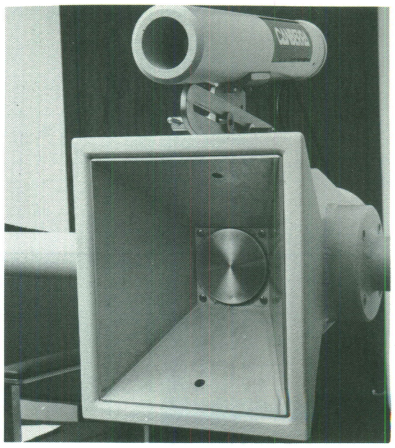
Shielded Chair

- Individual detectors for thyroid and body
- Body detector collimators enable a restriction of the field-of-view to the lungs or the GI tract
- Chair geometry optimized for 3" x 3" NaI(TI) body detector
- Special thyroid detector (1.5" dia. x 0.5") permits accurate and efficient measurements
- Lead filled chair minimizes background effects

By design, the shielded chair is capable of absolute determination of radioactive body burdens in the range of interest for the Nuclear Reactor Power Facility. Calibration of the chair was accomplished by phantom studies and measurements of persons with known body burdens and later expanded by cross-calibration with the whole body counting facility at the Massachusetts Institute of Technology's Radioactive Center.







The chair is lined with 0.5" of lead which constitutes a shielded pocket for the subject to be measured. The 3" x 3" body detector is mounted in a 2.0" lead shield that is open only in the direction of the chair. The built-in relationship between the chair and the detector results in a fixed-geometry 50cm arc whole body counting configuration (a standard whole body counting geometry) that may be calibrated to yield absolute results in terms of microcurie body burden.

A special collimator with a 1.5" dia. x 0.5" NaI(Tl) detector is mounted on top of the body detector for selectively measuring the radioactive content in the thyroid gland. Again, a reproduceable geometry and absolute counting is featured. The detector is provided with a 0.001 inch aluminum window to improve the counting efficiency for low energy emitters such as Iodine.

The field of interest for the body detector may be restricted to the lung field, the GI tract field, or may be opened up to include the entire trunk from the neck to the knees.

If it is known or suspected that an individual has been exposed to airborne activity that will represent a lung deposition, better accuracy and a better activity to background ratio is obtained by restricting the detector field-of-view to the lung area.

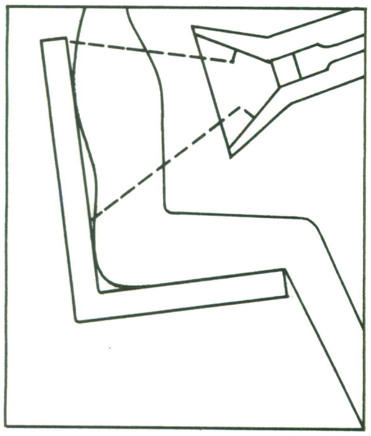
Similarly, by rotating the detector with the collimator still inserted, the field-of-view can be restricted to the GI tract field. This may be desirable in obtaining the GI content immediately after a known ingestion of activity.

Each whole body chair that is built includes a calibration of the system which is calibrated against an iron-room whole body counting system. All calibration sources are traceable to the U.S. National Bureau of Standards.

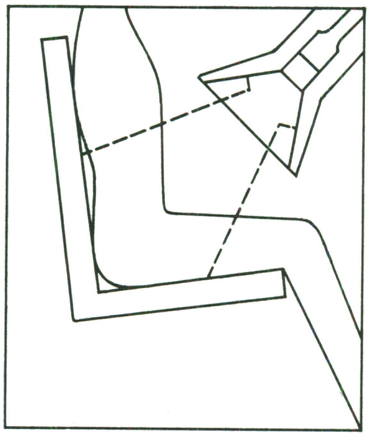
SYSTEM OPERATION

In the normal mode of operation, the 1.5" dia. x 0.5" NaI(Tl) detector views the thyroid gland of the subject seated in the chair and the 3" x 3" NaI(Tl) detector views the whole body. When the subject's data collections are completed, the pulse height data are transferred to the computer for analysis and/or storage. The two modes most commonly used are real time analysis or batch mode analysis. In the real time analysis mode, the data are analyzed immediately after collecting. This takes approximately 60 to 120 seconds depending on the type of mass storage the system has. In the batch mode, the subject's spectrum is stored on a cassette and at the end of the day, the tape is placed on the computer and all spectra are analyzed. During refueling operations or when the computer is not available, the batch mode may be desirable.

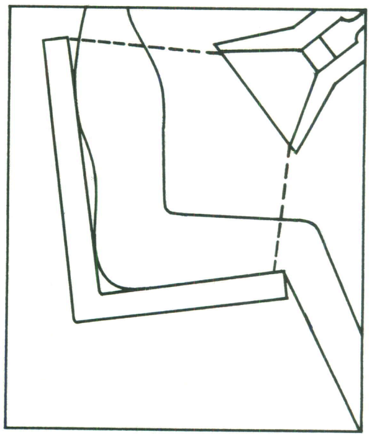
The capability and versatility of the 2230 Body Burden System lies in the application software. ABACOS, the body burden software, represents a new level in sophistication for environmental (NaI(Tl) detector) spectra. ABACOS has the capability of quantifying up to 30 isotopes in background level type spectra. This capability alone makes ABACOS unique in today's market. It is written entirely in FORTRAN IV, allowing it to be easily upgraded as new analysis algorithms are developed or modified for special applications. The 2230 Body Burden System is integrated into the Digital Equipment Corporation's (DEC) family of PDP 11 mini-computers. Since ABACOS is written under DEC's RT-11 Real Time Disk Operating System, maximum system flexibility is available to the user. Any of DEC's products that are supported by RT-11 are easily added to the system without software modifications. For example, the mass storage device can be a cartridge disk or dual floppy disk. The input/output device can be a video terminal, teletype, DECwriter, punched cards, mag tape, printer, etc. All this system configuration flexibility including the ability of ABACOS is available on PDP-11 computer with 32K bytes of memory.



Restricted Lung View



Resticted GI View



Collimators Removed for Whole Body View

ABACOS

- A new level of sophistication for real time analysis of low activity NaI(Tl) spectra
- Analysis of complex burden spectra in 60 seconds
- Separate libraries for Lungs, GI tract, Body and Thyroid
- Can be used with any bed or chair geometry systems
- Turn key operation

ABACOS (Automatic Burden Analyzing Computer Software) is designed for use with any Canberra Multichannel Analyzer that has a computer interface. Operation of ABACOS is simple and straightforward. The user collects a subject's spectrum (typically 5 to 10 minutes) and types ANALYZE - in as little as 60 seconds later, a complete isotopic burden analysis is accurately printed on the system's output device. A list of pertinent ABACOS commands are:

COMMAND	MEANING
ANALYZE	Perform complete body burden analysis
BACKGROUND	Treat the current spectrum as a background spectrum, perform an analysis and save background activities
CALIBRATE	Perform an energy calibration on one or both NaI(Tl) detectors
COLLECT	Put the MCA into the collect mode to accumulate pulse height spectra automatically followed by a TRANSFER
EFFICIENCY	Perform an efficiency calibration on one or both NaI(Tl) detectors
RETRIEVE	Retrieve a spectrum that has been stored on disk via the SAVE command
SAVE	Save the current spectrum on disk, in a file named by the user
TRANSFER	Transfer MCA memory contents to the computer
TYPE	Print a listing of the current spectrum

Since efficiency calibration is dependent on the detector and its surrounding geometry, ABACOS can be used with any geometry desired. Canberra has selected the chair geometry primarily for two reasons:

1. An internal dosimetry program is concerned with dose to the critical organs of the body, consequently shielding all other parts of the body from the field of view enables a more accurate estimate of the internal dose.

2. Presently there are no current Regulatory Guides for whole body counting; however, they are imminent. Authorities associated with recommending agencies to the NRC are suggesting an internal dosimetry program which specifically identifies the critical organs.

In ABACOS, a detector efficiency calibration is performed using "phantoms" containing radionuclides of known activities. A pulse height spectrum from a phantom is collected and analyzed, and the detection efficiency is calculated for each calibration gamma ray. Coefficients for calculating the detector efficiency at any given energy are then determined by least squares fitting, and saved on disk for use during analysis. Once an efficiency calibration has been performed, it need not be repeated unless the detector or detector geometry is changed for some reason.

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CANBERRA

The detector energy calibration procedure has been made as simple as possible. For a complete energy calibration, at least three distinct gamma ray energies are needed. After collecting and analyzing the calibration spectrum, a least-squares fit of energy versus pulse height is made to a second or third degree polynomial. (A third degree polynominal will be used if four or more calibration peaks are used.) At least a second degree polynomial is needed in order to accurately take into account the inherent nonlinearity of NaI detectors. In addition, a relation between energy and the widths of spectral peaks is also determined. Subsequent energy recalibrations may be made using a single gamma ray to correct for system gain drift, or two gamma rays to correct for both gain and zero drift. It is normally not necessary to redetermine the system nonlinearity unless some system component (detector, amplifier, etc.) is changed.

The algorithms used in ABACOS represent a new level of sophistication for the real time analysis of low activity spectra obtained with NaI(Tl) detectors. First, the background due to Compton interactions within the detector and collimator is estimated and subtracted before analysis. The problem of estimating the underlying background continuum in a NaI spectrum is complicated by the overlapping of spectral peaks associated with gamma rays of different energies. Due to this overlapping of peaks, a relative minimum in the spectrum may be significantly higher than the "true" background if it is not far enough removed from surrounding peaks. In whole body counting, the problem is further aggravated by the low count rates involved and the resulting large uncertainty in the data in each data channel.

In the past, most background subtraction algorithms have concentrated on locating minima in the spectrum, rejecting some of them on the basis of certain criteria, and approximating the background by some type of interpolation between the remaining minima. In order to accurately locate the minima, smoothing of the spectral data was usually performed. This had the undesirable side effect of raising the minima values and broadening the effective detector resolution, thus distorting the data. In addition, most of the criteria used to reject false minima were sensitive to the counting rate and the slope of the background. The background subtraction technique used in ABACOS is invariant with respect to counting rates and the slope of background.

After the estimated background has been subtracted from the original data, an iterative least-squares fitting technique is used to determine the areas of statistically significant spectral peaks corresponding to a library of gamma rays from isotopes of interest, and to correct the areas for interference affects from other isotopes. Activities are then calculated from the peak areas and previously determined detector efficiency data. Activities present in the environmental background may be optionally subtracted from the measured subject activities. Note that background activities, rather than raw background spectra, are subtracted; this improves the statistical accuracy of the result, and is insensitive to shifts in the detector energy calibration that can occur between the time background and subject spectra are accumulated. A report is then generated listing the isotopes present, their activities, and percent statistical uncertainty at the confidence level (one sigma, two sigma, etc.) specified by the operator during the initial program dialog. The quoted statistical uncertainty includes the uncertainty associated with the detector efficiency calibration.

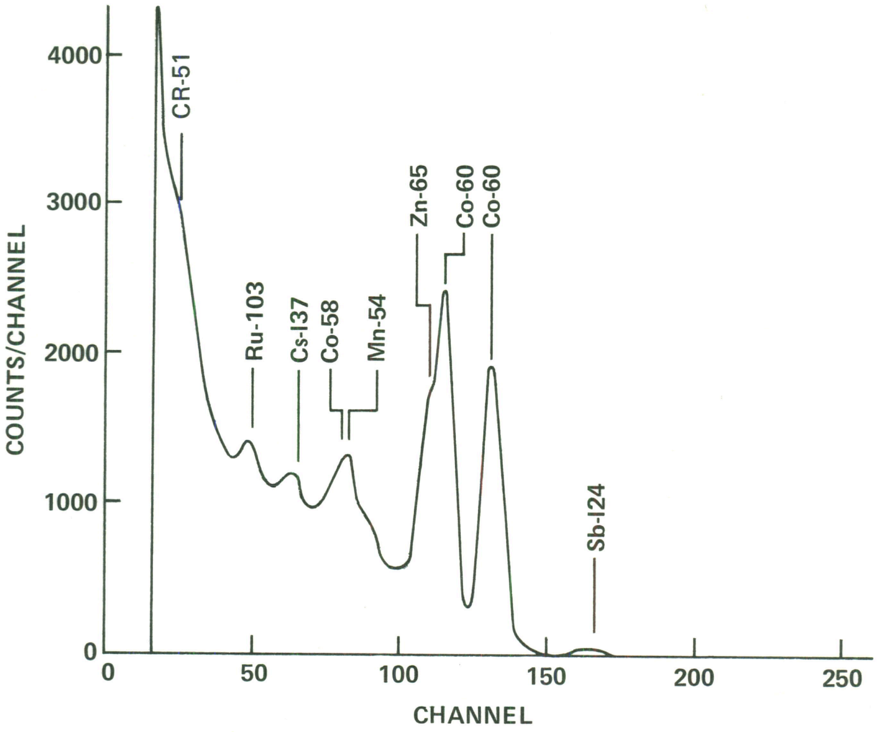
SYSTEM RESULTS

ABACOS provides the user with Libraries for the Thyroid, Lungs, GI tract and the Body. In each library the user can insert the desired maximum permissible organ burden for the isotopes selected. Because the burdens used by the International Council for Radiation Protection, Publication 2 are 1959 burdens, most users modify the burden values. ABACOS contains burden values based on ICRP Publication 2, and a dosimetric model reported by Skrable, et al[1].

A table is provided at right which illustrates the Minimum Detectable Activity (MDA) of the body detector for a **10 minute count.** The MDA is given at the 95% confidence level.[2]

The spectrum depicted below was taken from a pair of "clean overalls" just returned from the laundry at a Nuclear Power Reactor Facility. The coveralls were placed on the chair and measured for 10 minutes. An analysis on the "clean overalls" is performed by ABACOS on the following page.

Nuclide	MDA (μci)
^{51}Cr	0.112
^{54}Mn	0.010
^{59}Fe	0.019
^{58}Co	0.010
^{60}Co	0.010
^{65}Zn	0.017
^{95}Zr-Nb	0.010
^{103}Ru-Rh	0.012
^{106}Ru-Rh	0.052
^{124}Sb	0.010
^{134}Cs	0.010
^{137}Cs	0.010
^{140}La	0.012
^{144}Ce-Pr	0.135



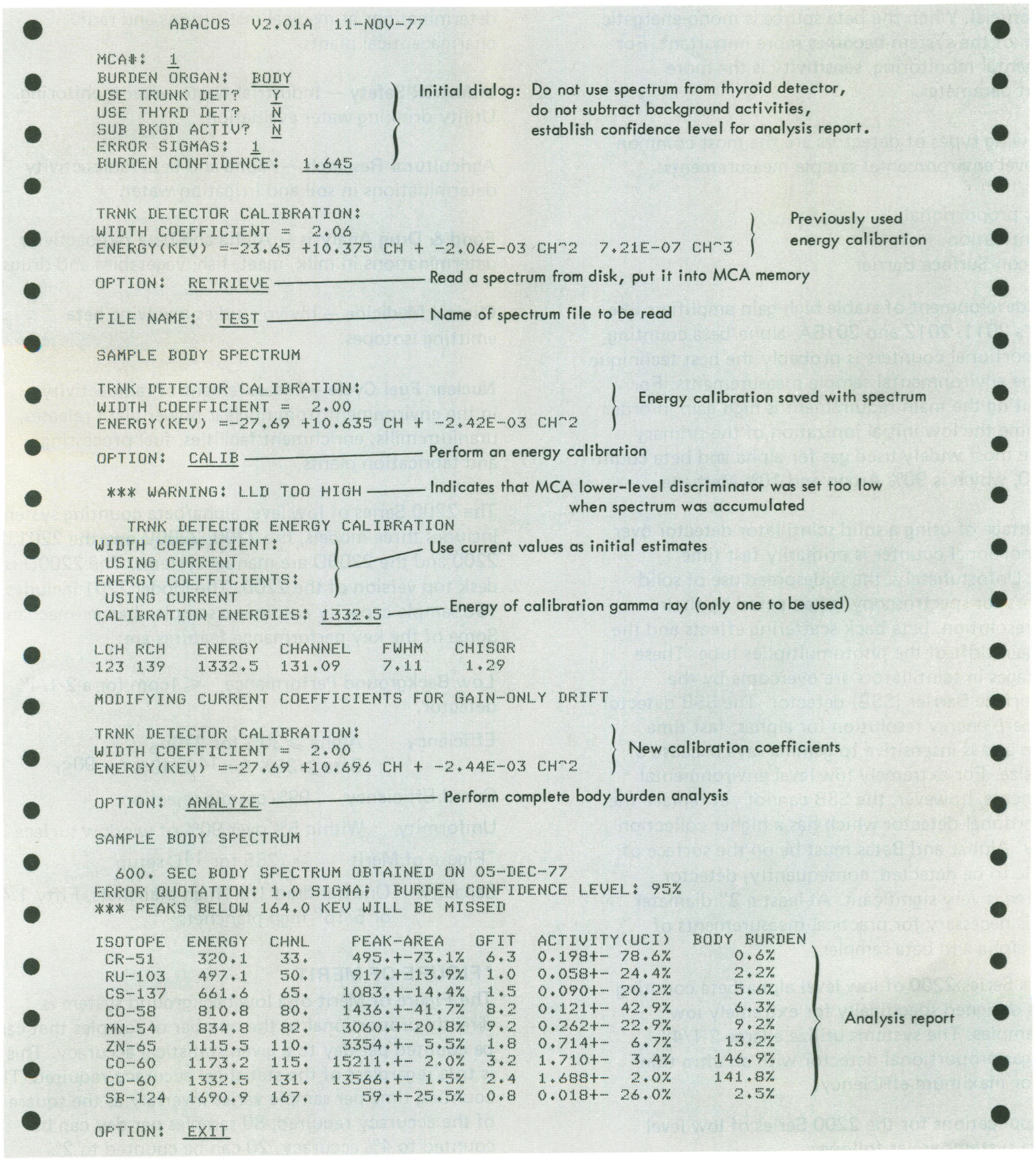
Actual NaI(Tl) Spectrum Taken at a Power Plant

[1] K.W. Skrable, G. Chabot, J. Harris and C. French, "Dosimetric Model for the Gastrointestinal Tract", Health Physics 28 (1975) 411.

[2] It must be noted that the MDA's listed include the identification of the particular isotope. Most MDA's published do not pertain to the identification of the particular isotope. For Body or Organ Burden measurements, identification of the particular isotope is important. MDA's without identification are considerably lower.

SAMPLE PRINTOUT

The computer printout below illustrates the capability of ABACOS. In this example, the software is first called from the system disk, some initial questions are answered, a spectrum is recalled from a disk file (using the RETRIEVE command), an energy calibration check is made and an analysis is performed. Responses made by the operator are underlined. To perform an analysis on the "coveralls", the user types in ANALYZE or simply AN as illustrated in the bottom portion of the printout.



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        ABACOS  V2.01A  11-NOV-77

    MCA#:  1
    BURDEN ORGAN:  BODY
    USE TRUNK DET?   Y
    USE THYRD DET?   N
    SUB BKGD ACTIV?  N
    ERROR SIGMAS:  1
    BURDEN CONFIDENCE:  1.645


    TRNK DETECTOR CALIBRATION:
    WIDTH COEFFICIENT =  2.06
    ENERGY(KEV) =-23.65 +10.375 CH + -2.06E-03 CH^2  7.21E-07 CH^3

    OPTION:  RETRIEVE

    FILE NAME:  TEST

    SAMPLE BODY SPECTRUM

    TRNK DETECTOR CALIBRATION:
    WIDTH COEFFICIENT =  2.00
    ENERGY(KEV) =-27.69 +10.635 CH + -2.42E-03 CH^2

    OPTION:  CALIB

     *** WARNING: LLD TOO HIGH

       TRNK DETECTOR ENERGY CALIBRATION
    WIDTH COEFFICIENT:
     USING CURRENT
    ENERGY COEFFICIENTS:
     USING CURRENT
    CALIBRATION ENERGIES:  1332.5

    LCH RCH    ENERGY  CHANNEL    FWHM    CHISQR
    123 139    1332.5  131.09     7.11     1.29

    MODIFYING CURRENT COEFFICIENTS FOR GAIN-ONLY DRIFT

    TRNK DETECTOR CALIBRATION:
    WIDTH COEFFICIENT =  2.00
    ENERGY(KEV) =-27.69 +10.696 CH + -2.44E-03 CH^2

    OPTION:  ANALYZE

    SAMPLE BODY SPECTRUM

      600. SEC BODY SPECTRUM OBTAINED ON 05-DEC-77
    ERROR QUOTATION: 1.0 SIGMA;  BURDEN CONFIDENCE LEVEL: 95%
    *** PEAKS BELOW 164.0 KEV WILL BE MISSED

    ISOTOPE  ENERGY  CHNL      PEAK-AREA   GFIT  ACTIVITY(UCI)  BODY BURDEN
     CR-51    320.1   33.      495.+-73.1%  6.3  0.198+- 78.6%       0.6%
     RU-103   497.1   50.      917.+-13.9%  1.0  0.058+- 24.4%       2.2%
     CS-137   661.6   65.     1083.+-14.4%  1.5  0.090+- 20.2%       5.6%
     CO-58    810.8   80.     1436.+-41.7%  8.2  0.121+- 42.9%       6.3%
     MN-54    834.8   82.     3060.+-20.8%  9.2  0.262+- 22.9%       9.2%
     ZN-65   1115.5  110.     3354.+- 5.5%  1.8  0.714+-  6.7%      13.2%
     CO-60   1173.2  115.    15211.+- 2.0%  3.2  1.710+-  3.4%     146.9%
     CO-60   1332.5  131.    13566.+- 1.5%  2.4  1.688+-  2.0%     141.8%
     SB-124  1690.9  167.       59.+-25.5%  0.8  0.018+- 26.0%       2.5%

    OPTION:  EXIT
```

Initial dialog: Do not use spectrum from thyroid detector, do not subtract background activities, establish confidence level for analysis report.

Previously used energy calibration

Read a spectrum from disk, put it into MCA memory

Name of spectrum file to be read

Energy calibration saved with spectrum

Perform an energy calibration

Indicates that MCA lower-level discriminator was set too low when spectrum was accumulated

Use current values as initial estimates

Energy of calibration gamma ray (only one to be used)

New calibration coefficients

Perform complete body burden analysis

Analysis report

LOW LEVEL ALPHA/BETA COUNTING SYSTEMS INTRODUCTION

In most spectrometer systems, energy resolution is considered a key parameter. It is nearly always balanced against sensitivity in the sense that the best resolution is usually accompanied by a sacrifice in sensitivity. Discrimination of beta-emitters from each other by spectral analysis is not generally practical due to the continuous spectrum of the betas; therefore, resolution is not so crucial. When the beta source is mono-energetic, resolution of the system becomes more important. For environmental monitoring, sensitivity is the more significant parameter.

The following types of detectors are the most common for low level environmental sample measurements:

- Gas proportional
- Scintillation
- Silicon Surface Barrier

With the development of stable high gain amplifiers like Canberra's 2011, 2012 and 2015A, alpha/beta counting with proportional counters is probably the best technique for routine environmental sample measurements. For beta counting the main requirement is high gain in order to overcome the low initial ionization of the primary betas. The most widely used gas for alpha and beta counting is P-10, which is 90% Argon and 10% Methane.

The advantage of using a solid scintillator detector over a gas proportional counter is primarily fast time response. Unfortunately, the widespread use of solid scintillators for spectroscopy is hampered by their intrinsic resolution, beta back scattering effects and the thermal gain drift of the photomultiplier tube. These disadvantages in scintillators are overcome by the Silicon Surface Barrier (SSB) detector. The SSB detector offers superb energy resolution for alphas, fast time resolution and is insensitive to gamma rays because of its small size. For extremely low level environmental measurements, however, the SSB cannot yet replace the gas proportional detector which has a higher collection efficiency. Alphas and Betas must be on the surface of the sample to be detected; consequently, detector surface area is very significant. At least a 2" diameter detector is necessary for practical measurements of low level alpha and beta samples.

Canberra's Series 2200 of low level alpha/beta counting systems is designed specifically for extremely low activity samples. The systems utilize a large 2-1/4" diameter gas proportional detector with an ultra thin window for maximum efficiency.

Typical applications for the 2200 Series of low level alpha/beta systems are as follows:

Environmental Studies — Routine water supplies, lakes and other large bodies of water.

Health Physics — Evaporated solutions, ashed residues, and "parent/daughter" measurements.

Radiochemistry — Decay studies, double isotope counting, beta energy checks, and alpha/beta separation.

Physics — Half-life studies, cross-section measurements, and flux mapping with foils.

Occupational Health — Alpha and beta health physics determinations at medical institutions and radio-pharmaceutical plants.

Industrial Safety — Industrial waste water monitoring. Utility drinking water evaluation.

Agricultural Research — Alpha and beta radioactivity determinations in soil and irrigation water.

Food & Drug Analysis — Alpha and beta radioactivity determinations in milk, meat, fish, vegetables and drugs.

Clinical Medicine — Invivo studies involving beta emitting isotopes.

Nuclear Fuel Cycle — Measurement of radioactivity in the environment from nuclear power plant releases, uranium mills, enrichment facilities, fuel processing and fabrication plants.

The 2200 Series of low level alpha/beta counting systems includes three models, the 2200, 2200D and the 2201. The 2200 and the 2200D are manual systems. The 2200D is a desk top version of the 2200. The Model 2201 includes a 100 sample capacity automatic sample changer mechanism. Some of the key performance features are:

Low Background Performance	⩽1cpm for a 2-1/4" detector.
Efficiency	Alpha ⩾30% for ^{210}Po Beta ⩾30% for ^{14}C, 40% for ^{90}Sr
Guard Efficiency	99% cosmic rejection
Uniformity	Within 5% over 90% of window surface
*Figure of Merit	⩾1285 for ^{14}C setup
Capacity	One hundred 1/8" high planchets, Fifty 1/4" or 5/16" high planchets

*FIGURE OF MERIT

The Figure of Merit of a low background system is directly proportional to the number of samples that can be counted per day to a given statistical accuracy. This is true regardless of the statistical accuracy required. The counting time per sample varies inversely as the square of the accuracy required, 80 samples per day can be counted to 4% accuracy, 20 can be counted to 2% accuracy, 5 to 1% accuracy, etc. But regardless of the statistical accuracy chosen, if counter A has a Figure of Merit 3 times that of counter B, three times as many samples per day can be counted with counter A as with counter B to the same accuracy.

Model 2200/2200D/2201 Ultra Low Level α/β Counting Systems

Features

- Ultra low level detection of alpha and beta radiation
- Gas flow proportional sample detector
- Sealed cosmic detector
- Accommodates planchets 2″ in diameter and random height
- 4π lead shield assembly
- 100 sample capacity
- Trouble free sample changer mechanism
- Readout options for TTY, small printer, RS232 devices, and the Canberra Daisy Chain

Description

INTRODUCTION

A Low Background Alpha/Beta Detection System consists of a highly efficient gas flow sample detector and a cosmic (or guard) detector. The two detectors are used in conjunction to distinguish true sample events from cosmic or interference radiation associated with the local environment. The detectors are set up to operate in an anticoincidence mode to detect the existence of sample counts and cosmic events. When cosmic or background causes an event, the system is gated off and the event is discarded. In this manner, only true or net alpha or beta counts are recorded. The system is ideally suited for measuring isotopes such as ^{14}C, ^{228}Ra, ^{89}Sr, ^{90}Sr, ^{99}Tc, ^{226}Ra, ^{210}Po, ^{230}Th, etc.

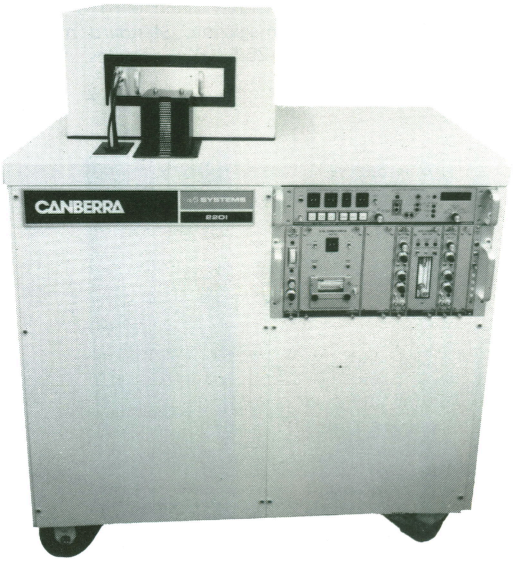
OPERATION

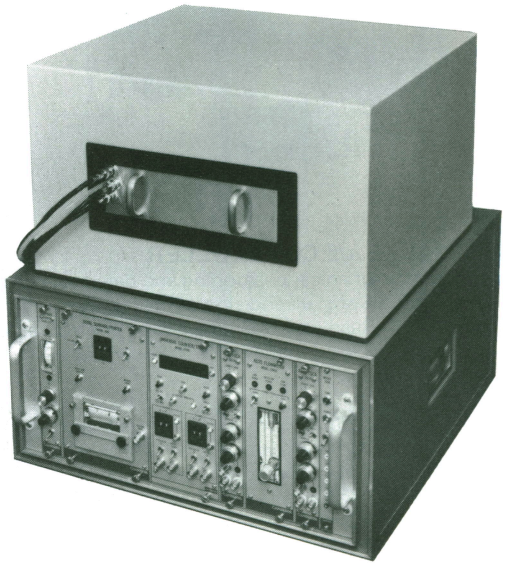
Figure 1 illustrates the basic system and components. The sample channel, which is used to measure net counts, consists of a preamplifier, amplifier and single channel analyzer. The guard channel, which is used to measure cosmic or background radiation, also consists of a preamplifier, amplifier, and single channel analyzer. The guard and sample detectors are biased by a single high voltage power supply. In operation, a sample count is processed through the sample channel and presented to the single channel analyzer. The single channel analyzer has two threshold settings: a lower level discriminator (LLD), and an upper level discriminator (ULD). The SCA output is simply the ULD minus LLD which is sometimes referred to as the window output. Typically, the single channel analyzer is set such that the SCA output represents beta particles and the ULD represents alpha particles. The outputs from the single channel analyzer are connected to a coincidence circuit.

In the event that the signal counted was not a sample count, but a cosmic event, the guard detector would send a signal through the guard channel (LLD) and present a logic pulse to the coincidence circuit. The coincidence circuit then prevents the scaler from recording the count. Similarly, the experiment collect time is gated off, and live time correction is made to improve statistics.

Upon completion of the collect time, the sample changer control logic removes the current sample and inserts a new one. The count cycle is then repeated and the scalers' data are logged on the output device.

Since the scaler provided in both the manual and automatic system is of the printing type, the output can take on a variety of forms. The usual LED display allows viewing of either channel or accumulated time via front panel selection. For data logging, either hard copy or computer storage may be desired. Both the 2200 Manual and 2201 Automatic Sample Changer systems can be interfaced to any one of Canberra's output NIM devices.





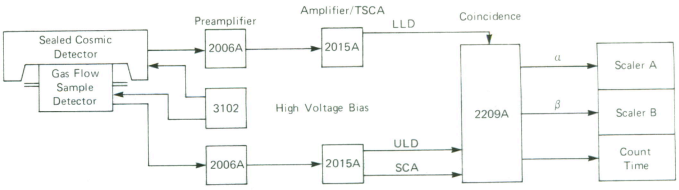


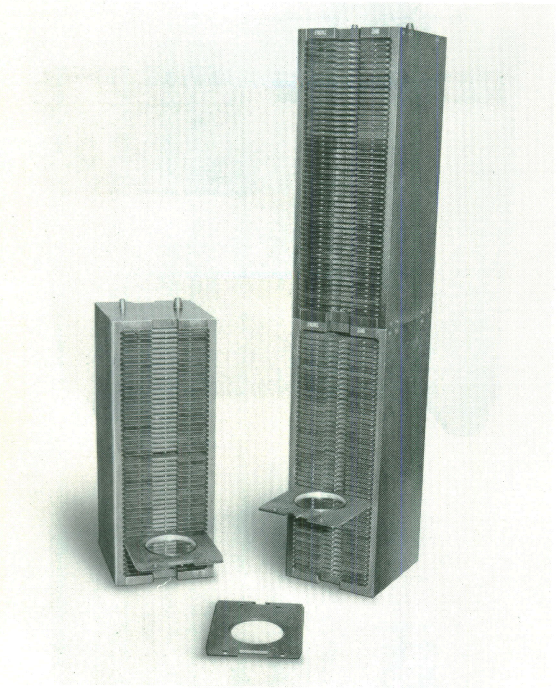
Figure 1 Low background α/β System.

Description (continued)

SAMPLE MAGAZINE

- Accepts various height planchets stacked at random
- Designed for 2" diameter planchets
- No stacking or alignment problems

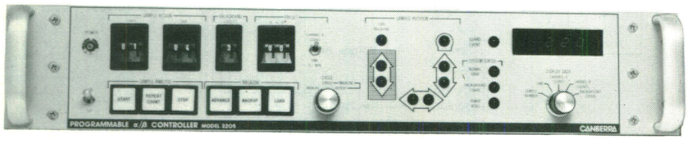
The magazines come in 50 sample modules, 2 modules snap together to provide 100 sample capacity. The magazine is also automatically aligned when placed into the magazine cavity. Detents are provided in the magazine to ascertain the alignment of planchet holders and prevents them from falling out. Either planchets 1/8"H or 5/16"H can be placed at random in the magazine. Standard magazines have a capacity of 50-1/8"H samples or 25-5/16"H samples.



PROGRAMMABLE α/β CONTROLLER

- Coordinates mechanical positioning and data analyzing
- Allows selection of start and stop sample groups
- Programmable Read Only Memories store control sequence
- Select Manual or Automatic modes of operation
- 6-digit LED display

The Programmable α/β Controller incorporates state-of-the-art Programmable Read Only Memories (PROM's). The PROM-based architecture offers a microprogram that controls a sequence of operations. This feature allows factory changes in the program to suit an individuals desired sequence of operations. The program selects desired inputs from the operator, limit sensors, external instruments etc. It then tests these inputs and, as a result of the test, performs a given output function, i.e, turn on a motor, light a lamp or send out a pulse to another device. It is the most flexible controller available and will satisfy any requirement.



CONTROLS

MANUAL:

START - moves a sample from the magazine in under the detector and begins counting. Counting will continue until the selected time interval or selected counts are reached

STOP - cause all processes to halt in a controlled manner

REPEAT COUNT - performs another count cycle on a sample that is under the detector

ADVANCE - magazine is lowered to the next sample

BACK UP - magazine is raised to the previous sample

LOAD - returns magazine to the load position

AUTOMATIC:

START - entire selected region of samples is processed as selected

STOP - causes all processes to halt in a controlled manner

CYCLE:

SINGLE - a single pass on the selected group of samples in the magazine. Upon completion, the magazine returns to the load position

REPEAT - the entire selected group of samples in the magazine is counted over and over until manually stopped

LED DISPLAY DATA

SAMPLE - 0 - 99

TIME - 0 - 99999.9 minutes

CHANNEL A - counts in channel A scaler

CHANNEL B - counts in channel B scaler

BACKGROUND REPEAT CYCLES - 0 - 9

STATUS INDICATORS

SAMPLE POSITION - indicates sample position at all times

LOAD MAGAZINE - indicates when magazine can be loaded

NORMAL COUNT - indicates a counting process is taking place

BACKGROUND COUNT - indicates an extended count is being made for background purposes

POWER RESET - initializes the system after a power failure and automatically restarts the system

GUARD EVENT - lights whenever a background count is detected by the guard channel

SET UP SWITCHES

START - 0 - 99 thumbwheel switch selects the first sample to be selected

STOP - 0 - 99 thumbwheel switch selects the last sample to be selected

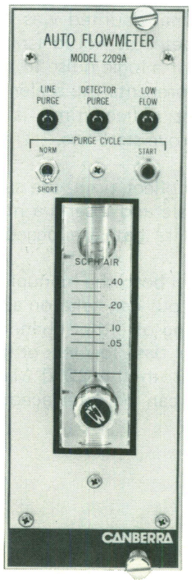
BACKGROUND CYCLES - 0 - 9 thumbwheel switch selects the number of background repeats

PRESET TIME/COUNTS - switch selects preset time or counts with two digit thumbwheel for N x 10^m counts or 0.1 minutes. N=0 thru 9, m=0 thru 5

AUTO FLOWMETER

- Automatic detector and gas line purge
- Low gas flow protection
- Coincidence control

The 2209A Auto Flowmeter automatically controls the gas flow under all conditions. When the system is turned on, the gas lines are automatically purged. After the lines are purged, the detector is purged for a preselected time. By first purging the gas lines and then the detector, moisture and contamination are reduced to a minimum. In addition, when there is a low or no gas flow condition, the 2209A shuts the high voltage off to protect the detector's anode wire.

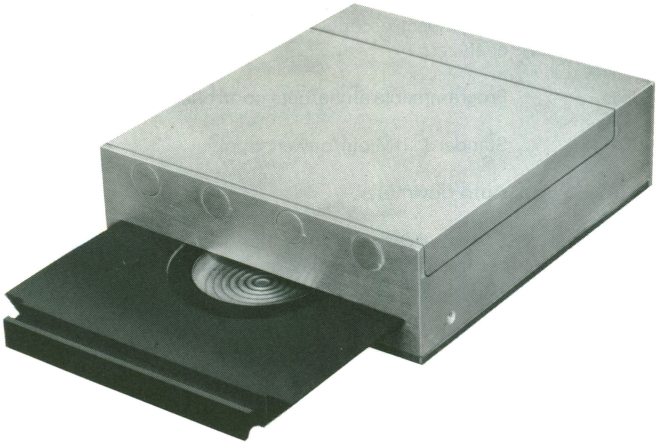


Description (continued)

DETECTOR

- Extremely stable low background flow counter with integral anticoincidence guard counter
- Contamination free sealed guard detector
- Ultra thin window - $80 \mu gm/cm^2$
- Matched detectors require only one high voltage power supply
- Background counts (shielded by 4" of lead) ⩽1.3 cpm

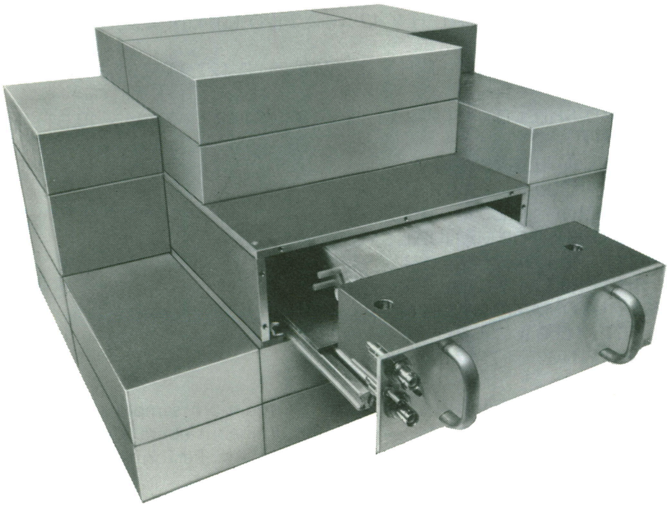
The integral detector assembly is designed for operation in or out of the shield. This unique feature allows for easy removal of the detector (just pick it up!) while it provides maximum protection for the detector assembly. The detector assembly is housed in a rugged aluminum casing which minimizes contamination and moisture buildup. A drawer is provided for sample insertion and when closed, the sample is precisely placed under the sample detector. The drawer is removed for operation in the 2201 system.



LEAD SHIELD

- Lead drawer face plate
- Ball bearing rollers
- Easily upgraded to Sample Changer Operation
- 4" of lead in all directions for 4π shielding

When the integral detector system is placed in the shield, it is completely surrounded by lead. Unlike other systems, the precision-formed sections coupled with ball bearing rollers allow the drawer to support the lead mounted in front of the shield's door. The unique design of the shield also allows the user to upgrade at any time to a Model 2201 Automatic Sample Changer System that accommodates 100 samples.



CABINET

- Rugged Portable Steel Cabinet
- 5" Roller Bearing Casters
- Wheel Locking Mechanism

The cabinet is designed for ease of operation and mobility. Despite the weight of 1300 pounds of lead the Model 2200 and 2201 systems can be moved around as easily as an office chair. Its dimensions allow it to fit through most standard size doorways. It is constructed entirely of steel. The Model 2200 is upgradeable to the Model 2201 Automatic Sample Changer System in less than 2 hours. The sample changer mechanism is bolted in beneath the detector section and the Model 2205 Programmable Controller replaces the blank 3-1/2"H x 19"W panel in the electronics section.

SAMPLE CHANGER MECHANISM

- Position accuracy ⩽0.002 inches
- Trouble free sample changer mechanism
- Optical switches for position sensing
- Stepping motor control

Designed into the Model 2201's sample changer mechanism is simplicity, reliability and precise repeatability. The magazine transport mechanism consists of lead screws coupled to stepping motors and optical switches which accurately sense position. For position sensing, most other sample changer mechanisms use mechanical switches which continuously require adjustment. The lead screws reduce the number of mechanical components to a minimum and eliminates the typical adjustments associated with changer mechanisms.

In addition, the mechanism is jam proof. The motors have been precisely selected to slip if a bind is encountered during travel. This feature provides complete protection to all components.

*Background performance is based on ^{14}C counting at a stable operating point and represents Beta background. Alpha background is considerably less.

Specifications

2200 Complete Manual System

7700	Low background 2″ gas flow counter with integral anti-coincidence guard counter and drawer for 2″ planchets, 80μgm/cm^2 window.
7701	Four-inch thick lead shield with 4π geometry and shielded drawer on roller bearings.
7702	Steel cabinet with 5″ locking wheels.
2006A	Two ultra-low noise proportional counter preamplifiers.
3102	High voltage power supply, 0-2kV.
2015A	Two spectroscopy amplifier/timing single channel analyzers.
1790C	Universal counter/timer.
2000	Standard NIM bin/power supply.
2209A	Auto flowmeter.
2200-ck	System accessories kit, includes: pressure regulator, gas line purifier, moisture detector, hoses and fittings, 10 planchets, 1/8″H x 2″ dia.

2200D Complete Desk Top Manual System

7700	Low background 2-1/4″ gas flow counter with integral anti-coincidence guard counter and drawer for 2″ planchets, 80μgm/cm^2 window.
7701	Four-inch thick lead shield with 4π geometry and shielded drawer on roller bearings.
5015H	Desk top cabinet
2006A	Two ultra-low noise proportional counter preamplifiers.
3102	High voltage power supply, 0-2kV.
2015A	Two spectroscopy amplifier/timing single channel analyzers.
1790C	Universal counter/timer.
2000	Standard NIM bin/power supply.
2209A	Auto flowmeter.
2200D-ck	System accessories kit, includes: pressure regulator, gas line purifier, moisture detector, hoses and fittings, 10 planchets, 1/8″H x 2″ dia.

Extra Cost Options:

2089	Scanner/Printer (fits in NIM bin).
1488	TTY print control (for use with Teletypes).
1788	EIA communications interface (for use with Hewlett-Packard calculators or PDP-11 computers).
9815A	Hewlett-Packard calculator.

2201 Complete Automatic System

7700	Low background 2″ gas flow counter with integral anti-coincidence guard counter and drawer for 2″ planchets, 80μgm/cm^2 window.
7701	Four-inch thick lead shield with 4π geometry and shielded drawer on roller bearings.
7702	Steel cabinet with 5″ locking wheels.
7703	100 sample capacity changer mechanism.
2006A	Two ultra-low noise proportional counter preamplifiers.
3102	High voltage power supply, 0-2kV.
2015A	Two spectroscopy amplifier/timing single channel analyzers.
2205	Programmable alpha/beta controller.
2000	Standard NIM bin/power supply.
2209A	Auto flowmeter.
2201-ck	System accessories kit, includes: pressure regulator, gas line purifier, moisture detector, hoses and fittings, 100 planchets, 1/8″H x 2″ dia.

SAMPLE DETECTOR

WINDOW - 800 μgm/cm^2
DIAMETER - 2
TYPE - gas flow
UNIFORMITY - $\leqslant$5% over 90% of window

COSMIC DETECTOR

SIZE - 5.75″ x 6.375″
TYPE - sealed, 1 atmosphere, gas mixture (90% Argon, 10% Methane)

FLOW GAS

Canberra specified research grade proportional (90% Argon, 10% Methane)

*EFFICIENCY

ALPHA - $\geqslant$30% for ^{210}Po
BETA - $\geqslant$30% for ^{14}C, 40% for ^{90}Sr

BETA BACKGROUND

For ^{14}C operation, $\leqslant$1.3 cpm

GUARD EFFICIENCY

$>$ 99% Cosmic detection

PHYSICAL

7702 CABINET - 41″H x 42″W x 24″D (104.14 x 106.7 x 60.96 cm)
7702D CABINET - 11″H x 21″W x 21″D (27.94 x 53.34 x 53.34 cm)
LEAD SHIELD - 18″W x 11″H x 16″D (45.72 x 27.94 x 40.64 cm)

WEIGHT

2200 MANUAL SYSTEM
NET - 1300 lbs. (585 kgs)
SHIPPING - 1500 lbs. (675 kgs).
2200D DESK TOP MANUAL SYSTEM
NET - 1050 lbs. (473 kgs).
SHIPPING - 1250 lbs. (563 kgs).
2201 AUTOMATIC SYSTEM
NET - 1500 lbs. (675 kgs).
SHIPPING - 1700 lbs. (765 kgs).

*Efficiency measurements are based on minimum sample to window-distance with a standard disk source. Simultaneous operation efficiency is dependent on the operating point selection. Performance requires Canberra specified gas.

System Software

Introduction

The software supplied with computer-based analysis systems is very probably the most important single component in the system, for no system—regardless of its hardware sophistication—can be any better than its system software.

With this as a guiding principle and a corporate goal of providing the best systems possible, Canberra is devoting many man years of effort to the development of Systems and Applications software. This effort, in combination with the excellent operating software provided by Digital Equipment Corporation (DEC) for the PDP-11® family of computers, has enabled Canberra to offer a powerful and flexible system with an extensive library of application software.

Canberra offers a variety of software for use on standard PDP-11 based data acquisition and analysis systems. Most Canberra software is supplied as part of a complete package utilizing either the RT-11® or RSX-11M® operating system, as supplied by DEC®. These software packages are supplied ready to run on the user's system, without the need for lengthy system generation procedures. The following sections give an overview of each Canberra software product; additional information is available from the Software Product Description for individual products. Contact your local salesman or representative for this literature.

Operating Systems

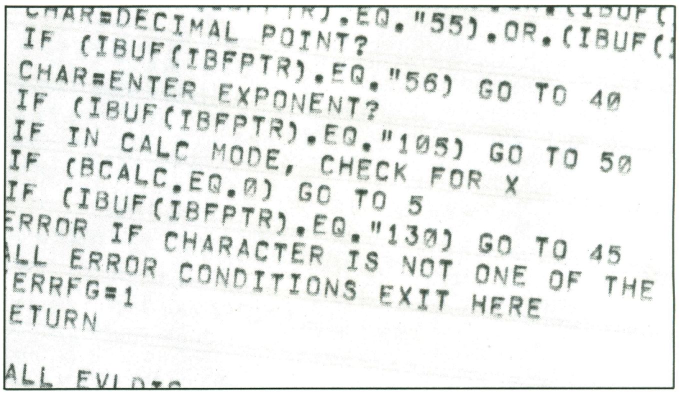
The Operating System software package is the base on which all other system software is built. A solid, reliable and flexable Operating System is a prerequisite to the development of any meaningful system software package. Because of this great importance and the need for an intimate knowledge of both current computer products as well as future developments, Canberra uses only standard DEC supplied operating system software. This ensures that our customers will always have a reliable field-proven Operating System, and guarantees compatibility with future DEC developments.

RT-11

RT-11 is a disk-based single-user real time operating system for PDP-11 mini-computers developed for interactive program development and/or on-line applications. Both single job (SJ) and foreground/background (FB) processing modes are supported by RT-11. In the foreground/background mode of operation, some type of real-time function is performed as a foreground (high priority) task, while a second (low priority) background task can be used to perform such operations as program development, text editing or data reduction. Although they operate independently, foreground and background tasks can communicate with each other via disk files and/or message transmission areas in memory.

In addition to a variety of program development utilities, RT-11 can support a number of high level language processors, including FORTRAN IV, BASIC, and Canberra's own CLASS. All standard DEC PDP-11 peripherals are supported by RT-11: cartridge disk drives, floppy disk drives, magnetic tape drives, line printers, graphics terminals, etc. In addition, Canberra supplied I/O drivers and subroutines are available to support a variety of data acquisition devices under RT-11.

RT-11 offers a BATCH processing facility, as well as a powerful indirect command file support independent of BATCH. Command files are user created files containing a series of system commands that can be executed without operator intervention.



```
                    TR).EQ."55).OR.(IBUF(
CHAR=DECIMAL POINT?
IF (IBUF(IBFPTR).EQ."56) GO TO 40
CHAR=ENTER EXPONENT?
IF (IBUF(IBFPTR).EQ."105) GO TO 50
IF IN CALC MODE, CHECK FOR X
IF (BCALC.EQ.0) GO TO 5
IF (IBUF(IBFPTR).EQ."130) GO TO 45
ERROR IF CHARACTER IS NOT ONE OF THE
ALL ERROR CONDITIONS EXIT HERE
ERRFG=1
ETURN

ALL EVL
```

Canberra supplies standard DEC RT-11 software, with patches as required for Canberra developed peripheral handlers and for the inclusion of certain DEC specified revisions. RT-11 is licensed for use on a single system by DEC, and is fully supported by Canberra when supplied as an integral part of a Canberra software package.

RT/TSX

TSX is a software package that operates with a standard unmodified RT-11 system to allow up to eight users to time-share the facilities of RT-11. Under RT/TSX, up to eight time-share users appear to be using their own independent RT-11 system. Most programs that run under RT-11 will run under TSX without modification. This includes most RT-11 utilities (EDIT, LINK, PIP, etc.), high level language processors (FORTRAN, CLASS, etc.), and some Canberra applications software. In addition, a variety of features not available with standard RT-11 are provided. These include automatic line printer spooling, user file access control, command files called with arguments, advanced terminal support and optional time-usage accounting.

The TSX software should be ordered as part of a Canberra RT-11 based software package, or as an add-on to a customer's existing Canberra supplied software. RT/TSX may be used on any model PDP-11 computer with 56K bytes of memory and RT-11 supported hard disk.

RSX-11M

RSX-11M is a disk-based real-time operating system developed by DEC for use on UNIBUS PDP-11 processors. This operating system provides an environment for the execution of multiple real-time tasks using a priority structured event-driven scheduling mechanism. Canberra supplies a standard version of RSX-11M that requires processors with hardware memory management (PDP-11/34, PDP-11/45, PDP-11/60, etc.). The system can support up to 124K words (248 Kb) of memory on processors other than the PDP 11/70, and up to 1920K words (3840Kb) on the PDP-11/70. Memory is logically divided into partitions by the system for the execution of system or user specified tasks. The maximum allowable partition size for any given task is 32K works (64Kb). Automatic memory compaction minimizes partition fragmentation.

RSX-11M offers complete program development facilities as well as a real-time response run-time system. Program development and real-time tasks can execute concurrently in systems with at least 96K

® PDP-11, RT-11, RSX-11, and DEC are registered trademarks of Digital Equipment Corporation, Maynard, MA.

Operating Systems (continued)

bytes of memory. The system's software priority levels enable the user to compile/assemble, debug and install tasks without affecting real-time task response.

A multi-user program development facility is available for systems with a recommended 160K bytes or more of memory. Passwords and LOGIN/LOGOUT, device access protection, a round-robin scheduler (running under the real-time executive), and concurrent execution of equal priority tasks via executive level swapping are provided.

Tasks can be written in MACRO-11 assembly language and optionally FORTRAN IV, FORTRAN IV—PLUS, PDP-11 COBOL, BASIC-11 and BASIC-PLUS-2. Sharable libraries and system support for user-created libraries are provided. The EDI text editor, the EDT DEC editor, utilities, symbol cross-reference, and task memory dump facility are provided to assist task development and check-out.

The RSX-11M file system provides automatic space allocation and file structures for all block-structured devices.

Indirect command file support provides extremely powerful batch-like facilities. A terminal user can create a file containing system commands. The system can then be instructed to execute the commands in the file without operator intervention. The indirect file processor can be executing command files concurrent with real-time task execution.

RSX-11M is licensed for use on a single system by DEC, and is fully supported by Canberra when supplied as an integral part of a Canberra software package.

Programming Languages

In addition to the assembly language programming capability provided by either of the above Operating Systems, all Canberra computer-based analysis systems may include one or more high level programming languages. The various languages available are described briefly in the following sections.

HIGH LEVEL LANGUAGE PROCESSORS

CLASS

CLASS (**C**anberra **L**aboratory **A**utomation **S**oftware **S**ystem) is an interpretive high level language developed specifically for laboratory data acquisition and analysis. It is as easy to use as BASIC, yet has the computational power of FORTRAN. CLASS is available with RT-11 only. In addition to support for standard RT-11 I/O devices, CLASS provides access to a variety of Canberra manufactured data acquisition devices via the following functions:

1788 Functions: A set of CLASS commands allowing the user to communicate with up to eight Model 1788 EIA Communications Interfaces. Standard with all versions of CLASS.

MCA Functions: A set of CLASS commands allowing control of and Bidirectional data transfer from up to eight Model 8100/8180 MCA's with Option 14 interfaces, or Series 80 MCA's with Model 8671 interfaces. Supplied with versions of CLASS to be used with QUANTA and JUPITER systems.

DATANIM Functions: A set of CLASS commands to control a single Model 6911 Computer Interface, and up to two Model 6726 Telecomputer Interfaces. Supplied with versions of CLASS to be used with DATANIM systems.

USER Written Functions: Assembly language routines may be written in accordance with certain conventions and linked with CLASS object files to provide custom analysis or device access functions. These functions are accessed via a "CALL" command in CLASS.

FORTRAN IV

FORTRAN IV Compilers for an extended superset of the ANSI standard FORTRAN IV language are available for use with RT-11 and RSX-11M. These Fortran IV compilers are designed to minimize the size of executable programs. Extensive optimizations such as common subexpression elimination, array vectoring and local code sequence tailoring decrease the size and increase the speed of object programs. Object code is produced without using temporary files, and no intermediate assembly step is required. These are standard compilers developed by DEC, including all applicable patches published by DEC. The appropriate FORTRAN compiler is required if Canberra software packages written in FORTRAN IV are to be modified by the user.

Several optional subroutine packages are available to allow Canberra manufactured data acquisition products to be accessed from user written FORTRAN IV programs:

FT8100:	Subroutines for control of and bidirectional data transfer from up to eight 8100/8180 MCA's with Option 14 interfaces or Series 80 MCA's with Model 8671 interfaces.
FT8673:	Subroutines for control of and bidirectional data transfer from up to eight Series 80 or 40 MCA's with Model 8673/4273 high speed computer interfaces.
FT1788:	Subroutines for control of up to eight Model 1788 NIM Communications Interfaces.
FT6726:	Subroutines to control up to two Model 6726 DATANIM Telecommunications Interfaces.
FT6911:	Subroutines to control a single Model 6911 DATANIM Computer Interface (RT-11 only).
FT2221:	Subroutines to control up to two Model 2221 Motion Control Interfaces (RT-11 only).
FT86MP:	Subroutines for control of and bidirectional data transfer from up to 8 Series 80MP units with 8673MP interfaces.

BASIC

BASIC is a high-level conversational programming language, developed at Dartmouth College, that uses simple English-like statements and familiar mathematical notations to perform an operation. Because of its simplicity, BASIC reduces programming time for developing applications programs.

Standard versions of DEC BASIC are supplied for use with either the RT-11 or RSX-11M operating systems. Both the RT-11 and RSX-11M versions of BASIC are interactive interpretive compilers that allow highly efficient use of memory and other system resources. BASIC features include:

- Support of real, integer and string data types.
- Immediate mode statements for debugging and desk calculator usage.
- Virtual arrays using mass storage files.
- Chaining with COMMON to accommodate large programs.
- CALL facility for invoking assembly language subroutines.

The RT-11 Instrumentation BASIC package includes routines that may be accessed via CALL statements to communicate with Canberra manufactured data acquisition devices. These routines allow:

- Control of bidirectional data transfer from up to eight 8100/8180 MCA's with Option 14 interfaces or Series 80 MCA's with Model 8671 Interfaces.
- Control of up to eight Model 1788 NIM Communications Interfaces.
- Control of up to two Model 6726 Datanim Telecommunication Interfaces.
- Control of up to eight Model 2221 Motion Control Interfaces.

Application Software

While there is no question that good, solid Operation Systems and Language Processors are vital elements in a total system software package, it is important to remember that they are a means to an end and not the end result themselves. They are simply the tools used to provide the end product: Application Software that solves your particular problems.

CLASS APPLICATION SOFTWARE

QUANTA Commands

A set of short CLASS programs that allow control of Model 8100 and 8180 Multichannel Analyzers, or S-80/8671 via a simple set of interactive commands.

SPECTRAN III

A set of CLASS programs and data files for sophisticated analysis of complex pulse height spectra obtained from Ge(Li) spectrometer systems. Spectra may be analyzed directly from Model 8100/8180 MCA's and Series 80 Processors with 8671 interface, or from disk files.

SPECTRAN F

SPECTRAN-F is an application software package for performing rapid and accurate analysis of spectra obtained with germanium detectors. This software may be run under either the RSX-11M or the RT-11 operating system on Digital Equipment Corporation PDP-11 computers in conjunction with a Series-80, Series-40, or model 8100 Canberra Multichannel Analyzer (JUPITER or QUANTA systems). SPECTRAN-F is written in FORTRAN-IV in order to provide fast execution speed. SPECTRAN-F is operated from a terminal, and is user-oriented by always prompting the input needed.

SPECTRAN-F provides the functions needed for germanium spectra analysis. These are:

- Energy calibration
- Efficiency calibration
- Peak search
- Peak net area calculation
- Isotope identification
- Quantitative analysis of specific activities
- Multiplet deconvolution
- Minimum detectable activity analysis
- "E-bar" average energy calculation
- Radionuclide library editing

GAMMA-M

GAMMA-M performs rapid and accurate analysis of gamma ray spectra obtained with sodium iodide (NaI) scintillation detectors. This software may be run under either the RSX-11M multi-user or the RT-11 single-user operating system on Digital Equipment Corporation PDP-11 computers in conjunction with a Canberra model Series-80, Series-40, or 8100 Multichannel Analyzer. The sodium iodide software is written in FORTRAN in order to provide fast execution time. It is operated from a terminal, and is user-oriented by always prompting the input needed.

The sodium iodide software performs the following functions:

- Energy calibration
- Efficiency calibration
- Peak net area calculation
- Isotope identification
- Quantitative analysis of specific activities
- Minimum detectable activity analysis

QA

The Quality Assurance (QA) software package provides the capability for performing a calibration check of germanium [both Ge(Li) and HpGe] detectors. The software produces a quality assurance report that gives current values, or current values and differences from reference values, for:

- germanium detector system gain shifts,
- germanium detector system resolution,
- germanium detector system efficiency.

ABACOS

The ABACOS (**A**utomatic **B**urden **A**nalyzing **CO**mputer **S**oftware) program determines the radionuclide body burden of a person being analyzed in the standard shielded chair. Organ doses for the scanned and critical organs (body, thyroid, lung, or GI tract), are determined by using the single-uptake model defined in ICRP Publication 2 and ANSI Standard N343-1978.

Pulse height data are obtained with two sodium iodide scintillation detectors; one for the thyroid and one for the body, lungs, or GI tract. The data are collected in a multichannel analyzer that is interfaced to a PDP-11 computer.

The basic functions provided by the software are:

- Data collection in the multichannel analyzer
- Perform detector energy calibration
- Perform detector efficiency calibration
- Perform body burden analysis
- Calculate dose commitment
- Print results or save on disk

The software performs spectrum analysis by an interative technique for removing the background continuum under peaks that is due to compton interaction within the detector and collimator. This technique is based upon eroding the peaks mathematically into the level of the true gackground. For sodium iodide spectra this method is fast and well suited to the low count rates involved. The peak areas are then determined by least-square fitting in order to calculate intensities and dose levels.

Graphics Plotter Software

The following Hewlett Packard graphics plotters are supported for plotting spectral data:

- HP7221B Color Graphics Plotter (Canberra model 5204)
- HP7220 Color Graphics Plotter (Canberra model 5206)
- HP7225 Graphics Plotter (Canberra model 5207).

All the software for these plotters is written in FORTRAN IV and versions are available for RT-11 and RSX-11M operating systems.

Spectra can be plotted from Series-80, Series-40, 8100 or 8180 Multichannel Analyzers interfaced to the computer, or from data already stored on disk. Data points may also be entered manually. Other features of these software packages are:

- Interactive dialogue for option selection
- Automatic data scaling
- Linear, log, or square root data scaling
- Variable length axes
- Up to four color pens (color graphics plotters only)
- Plot label entry.

Disk Conversion Program

The Series-80 Multichannel Analyzer can be inferfaced to a floppy disk unit peripheral device for storage independent of a computer. The floppy disks produced can be read on a standard DEC RX01 or RX02 floppy disk drive. The data can be then transferred to a SPECTRAN-F compatible data file. This program operates under the RT-11 operating system.

CANSCAN

The CANSCAN software package is used with the model 2220 Segmented Gamma Scanner systems. These systems provide the capability for performing a complete U-235 and PU-239 assay in low-density waste in either 55-gallon drums or 5-gallon cans. The RT/CANSCAN software, written in BASIC, operates under the RT-11 operating system.

The software controls operation of a dual axis positioning system to rotate and vertically move the drum or can, and data collection of a germanium detector spectrum in a multichannel analyzer. Four system functions are controlled by pushbuttons on the system control panel. These functions are:

Application Software (continued)

CALIB - perform system calibration
ASSAY - perform data analysis and produce assay report
INIT - perform system initialization; allow user to specify system parameters
ABORT - terminate current function and wait for next control button to be pushed.

Remote Terminal Software

DEC operating systems include software to operate the console terminal, which is the only terminal under RT-11. A second terminal may be implemented under RT-11 at a remote location by use of software that transfers control and input/output. This remote terminal can then relinquish control back to the primary terminal. This software is furnished as a standard item in the RT-11 operating system.

Software Licenses

All software obtained from Digital Equipment Corporation is furnished under a license for use on a single computer system for which it is purchased. Licensed software, or any copies thereof, may not be made available to any other person except for use on system for which it was purshased. Title to and ownership of the software shall at all times remain with Digital.

Canberra developed software is likewise supplied for use only on a specific computer system. Use of such software on any other system must be approved in writing by Canberra.

ACCESSORIES 6

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A. Peripherals 306

B. Cables and Connectors 313

C. Cabinets 315

APPLICATION GUIDE – MCA AND COMPUTER PERIPHERALS

Item	Description	Series 30	Series 40	Series 80	Series 88	Computer Systems
5102	DECwriter II LA36 Current Loop	Requires C1405 Cable	Requires C1405 Cable	Requires C1405 Cable	Requires C1405 Cable	Requires 5711 or 5711V, (if used for other than console device).
5105	DEC VT55 CRT Terminal	N/A	N/A	N/A	N/A	Requires 5711 or 5711V, (if used for other than console device).
5107-1,2*	TTY KSR 43 Terminal with Current Loop Cable (C1406)	Yes	Yes	Yes	Yes	Requires 5711 or 5711V, (if used for other than console device).
5109	DECwriter III LA120 High Speed Terminal	Requires 3100-09 and C1500 Cable	Requires C1500 Cable	Requires 8652-G or 8652-GX	Requires 8652/MP-G or 8653/MP-GX	Requires 5711 or 5711V, (if used for other than console device).
5110	DEC VT-100 CRT Terminal	N/A	N/A	N/A	N/A	Requires 5711 or 5711V, (if used for other than console device).
5112	DECwriter IV LA38	Requires 3100-09 and C1500 Cable	Requires C1500 Cable	Requires 8652-G or 8653-GX	Requires 8652/MP-G or 8653/MP-GX	Requires 5711 or 5711V, (if used for other than the console device).
5113-1,2*	TTY ASR 43 Terminal with Paper Tape Punch and Reader. Includes Current Loop Cable C1406.	Requires C1406 Cable	Requires C1406 Cable	Requires C1406 Cable	Requires C1406 Cable	N/A
5201	Houston X-Y Point Plotter 2600 CZ-DM/DN	Requires 3100-03, 3100-05A, 3100-05B, or 3100-05C	Requires 4251	Requires 8651	Requires 8651	N/A
5202	HP X-Y Point Plotter 7004B	Requires 3100-03B and 3100-03, 3100-05A, 3100-05B, or 3100-05C	Requires 4251 and 4251B	Requires 8651 and 8651B	Requires 8651 and 8651B	N/A
5206	HP Color Graphics Plotter 7220	N/A	Requires 4253	Requires 8652-A or 8653-AX	Requires 8652/MP-A or 8653/MP-AX	Requires 5711 or 5711V, (if used for other than the console device).
5206T	Same as above with Paper Advance	N/A	Requires 4253	Requires 8652-A or 8653-AX	Requires 8652/MP-A or 8653/MP-AX	Requires 5711 or 5711V, (if used for other than the console device).
5207	HP Single Pen Graphics Plotter 7225	N/A	Requires 4253	Requires 8652-A or 8653-AX	Requires 8652/MP-A or 8653/MP-AX	Requires 5711 or 5711V, (if used for other than the console device).
5308	Facit 4070 Punch with RS232 Interface	Requires 3100-09 and C1501 Cable, 30 char/sec	Requires C1501 Cable. 60 char/sec	Requires 8652-B or 8653-BX, 60 char/sec	Requires 8652/MP-B or 8653/MP-BX, 60 char/sec	N/A
5309	Facit 4030 120 char/sec Paper Tape Reader with RS232 Interface	Requires 3100-09 and C1502 Cable	Requires C1502 Cable	Requires 8652-C or 8653-CX	Requires 8652/MP-C or 8653/MP-CX	N/A
5310-1,2*	TTY 4350 30 char/sec Paper Tape Punch/Reader with RS232 Interface and Cable	Yes	Yes	Yes	Yes	N/A

*Note-1 designates 110V, 2 designates 220V

Item	Description	Series 30	Series 40	Series 80	Series 88	Computer Systems
5408	9 track Mag Tape 800 BPI 10.5 in. Reel	N/A	N/A	N/A	N/A	Requires one SPC Unibus Computers only
5410	9 track Mag Tape 800 BPI 7 in. Reel	N/A	N/A	N/A	N/A	Requires one SPC Unibus Computers only
5411	Cassette Tape	Requires 3100-09	Yes	Requires 8652-E or 8653-E	Requires 8652/MP-E or 8653/MP-EX	N/A
5412	Pertec 7840 Mag Tape. 9 Track, NRZI, 800 BPI, 25 ips, 7 in. Reel	N/A	Requires 4254 and 8531A/9	Requires 8661	Requires 8661/MP	N/A
5413	Pertec 8840 Mag Tape. 9 Track, NRZI 800 BPI, 25 ips, 10½ in. Reel	N/A	Requires 4254 and 8531 A/9	Requires 8661	Requires 8661/MP	N/A
5414	Pertec 8840 Mag Tape. 9 Track, NRZI 800 BPI 45 ips,10½ in. Reel	N/A	N/A	Requires 8661	Requires 8661/MP	N/A
5507	DEC LA 120R for Unibus Computers	N/A	N/A	N/A	N/A	Requires one SPC
5507V	DEC LA 120R for QBUS (LSI-11) Computers	N/A	N/A	N/A	N/A	Requires Q Bus Board slot.
5508	IDS 445 Printer with RS232 interface and C1503 cable	Requires 3100-09 and C1503 cable	Requires C1503 cable for Print Only, and 4252 for Print/Plot	Requires 8652-F or 8653-FX and C1503 Cable	Requires 8652/MP-F or 8653/MP-FX	N/A
5607	DEC RL-01 5 M Byte Cartridge Disk and RL-11 Unibus Controller for up to 4 Disks	N/A	N/A	N/A	N/A	Requires One SPC
5607V	DEC RL-01 and RLV-11 same as above for Q Bus (LSI-11) Computers	N/A	N/A	N/A	N/A	Requires Q Bus board slot
5608	DEC RL-01 Cartridge Disk	N/A	N/A	N/A	N/A	Requires 5607 or 5607V
5609	DEC RX-211 Dual Density, Dual Floppy Disks for Unibus Computer	N/A	N/A	N/A	N/A	Requires one SPC
5609V	DEC RXV-21 Dual Density, Dual Floppy Disks for Q Bus (LSI-11) Computer	N/A	N/A	N/A	N/A	Requires Q Bus Board slot
5610	DEC RL-02 10 M Byte Cartridge Disk and RL-211 Unibus Controller for up to 4 Disks	N/A	N/A	N/A	N/A	Requires one SPC
5610V	DEC RL-02 and RLV-21. Same as above for Q Bus (LSI-11) Computers	N/A	N/A	N/A	N/A	Requires Q Bus Board slot
5611	DEC RL-02 Cartridge Disk	N/A	N/A	N/A	N/A	Requires 5610 or 5610V
HC-2	Polaroid 9 inch CRT Camera	Yes	Yes	N/A	N/A	N/A
HC-3	Polaroid 12 inch CRT Camera	N/A	N/A	Yes	Yes	N/A

Peripheral Devices

SERIES 5000

Hard Copy Terminals

Model 5107 TTY 43 Teleprinter

- Keyboard with 132 column, 30cps printer
- Prints full 94 ASC11 character set
- Dot matrix impact printhead
- Specify 5113 for Terminal with Punch and Reader

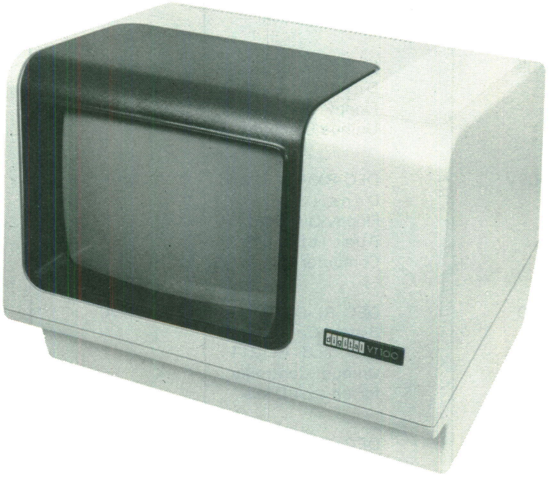
Model 5102 LA36 DECWriter 11

- Keyboard with 132 column 30cps printer
- Uses standard non-treated paper
- Separate numeric keypad to speed input

Video and Graphic Terminals

Model 5105 VT55 Graphics Terminal

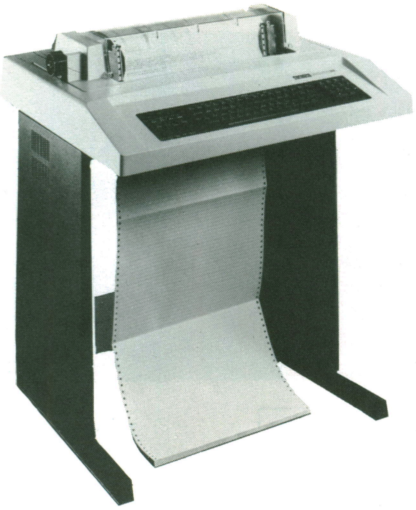
- Keyboard with 80 column by 24 line display
- Graphics screen resolution 512X by 236Y
- Optional hard copy unit
- RS232 Interface



Model 5110 VT100 CRT Terminal

- Keyboard with 80 column by 24 line display
- Separate numeric keypad
- RS232 Interface
- Speeds up to 9600 baud

Printers



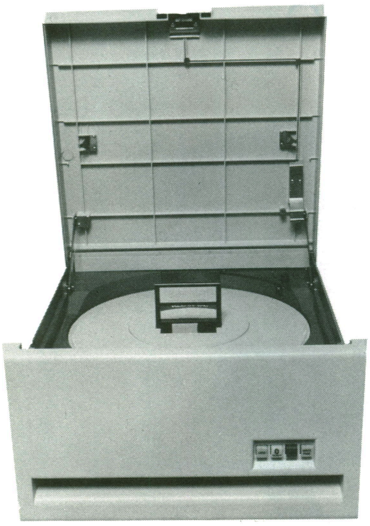
Model 5109 LA120 DECwriter III Teleprinter

- Keyboard with 132 column, 120cps printer
- RS232 Interface
- Selectable baud rates 110 to 9600
- Prints up to 6 part forms

Model 5507/5507V DEC LA120-R

- 132 column, 180cps printer
- Bidirectional printing
- Set-up functions
- UNIBUS or Q BUS Interface

Disk Systems



Model 5607/5607V DEC RL01 Cartridge Disk

- 5.2 Megabytes storage per cartridge
- 55msec average seek time
- 512K bytes/sec. transfer rate

5610/5610V DEC RL02 Cartridge Disk

- 10.4 MByte/Cartridge
- 55msec Seek time
- 512 Bytes/sec transfer rate

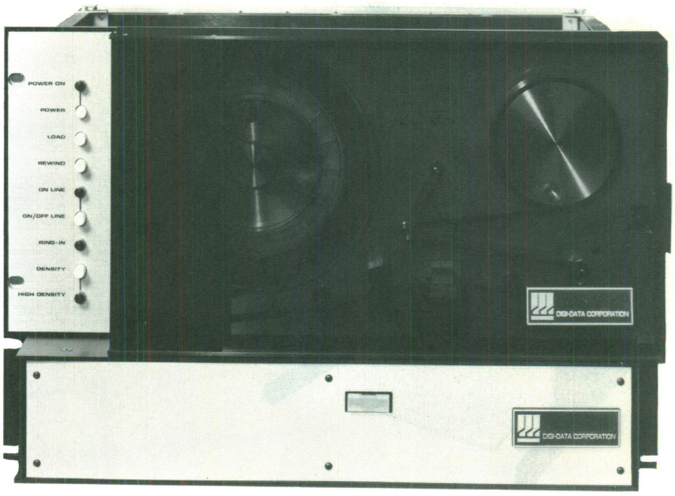
Model 5609/5609V DEC RX02 Dual Drive Dual Density Floppy Disk

- 512K bytes of storage per diskette
- 263msec average access time

Magnetic Tape Systems

Model 5408 Magnetic Tape System

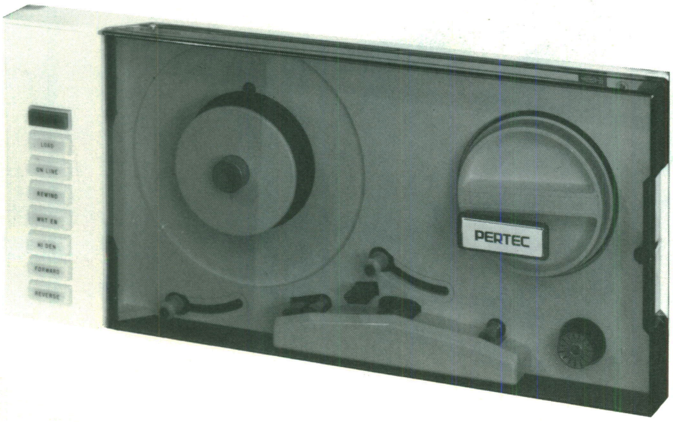
- 10.5″ reel, 9 track
- 45 ips, 800 BPI
- 36kHz transfer rate
- Includes UNIBUS interface


POWER ON
POWER
LOAD
REWIND
ON LINE
ON/OFF LINE
RING-IN
DENSITY
HIGH DENSITY
DIGI-DATA CORPORATION
DIGI-DATA CORPORATION

Model 5410 Magnetic Tape Interface

- 7″ reel, 9 track
- 25 ips, 800 BPI
- 20kHz transfer rate
- Includes UNIBUS interface

Magnetic Tape I/O



Model 5412 PERTEC Magnetic Tape

- 7″ Reel, 9 track
- 25 ips, 800 BPI, NRZI
- 20kHz transfer rate

Model 5413 PERTEC Magnetic Tape

- 10.5″ Reel 9 track
- 25 ips, 800 BPI, NRZI
- 20kHz transfer rate

Model 5414 PERTEC Magnetic Tape

- 10.5″ Reel, 9 track
- 45 ips, 800 BPI, NRZI
- 36kHz transfer rate

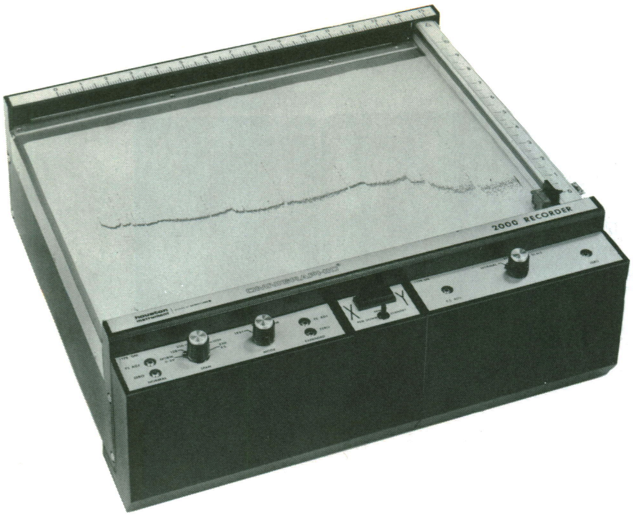
Cassette Tape I/O

COUNTER
AUTO STOP SYSTEM
PLAY
CANBERRA
DIGITAL CASSETTE RECORDER
MODEL 5411

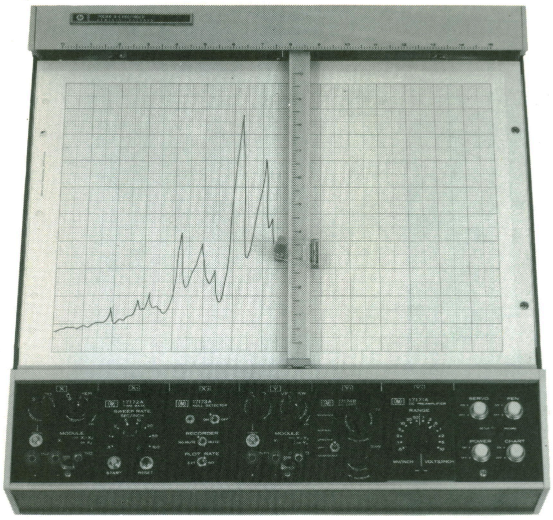
Model 5411 Digital Cassette Recorder

- Low cost true digital cassette I/O for the MCA's
- Record Time <105sec for a 1024 channel spectrum
- Storage capacity of 50 1K Binary spectra per cassette
- Digital counter and fast forward for rapid spectrum search

X-Y Plotters

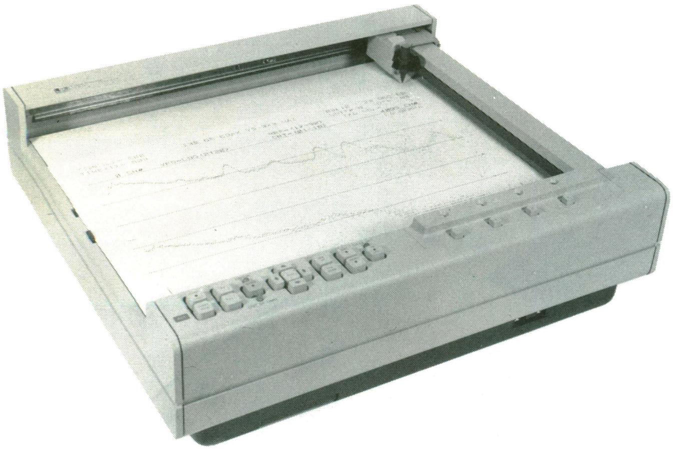


Model 5201 Houston Plotter
- Line or point plot
- 12 points/second
- Digital expansion and automatic calibration

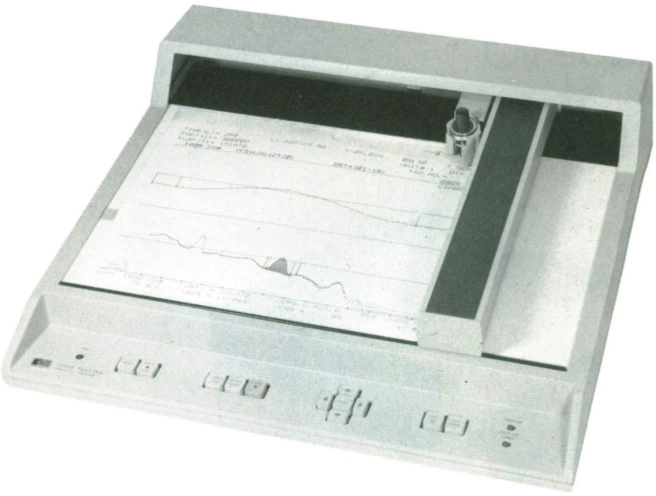


Model 5202 H.P. 7004B Plotter
- Line or point plot
- 50 points/second

Graphics Plotters

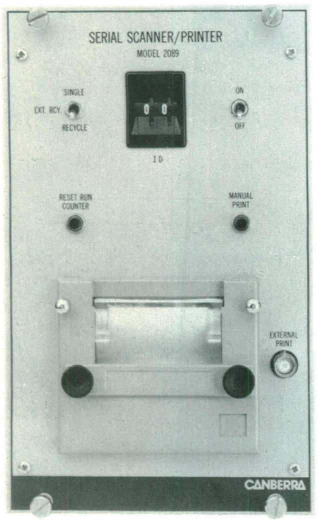


Model 5206 HP 7220
- Color graphic plotter
- Standard 11" x 17" chart paper
- Optional Paper Advance



Model 5207 HP 7225 Graphics Plotter
- Single Pen
- RS232 Interface

Printers



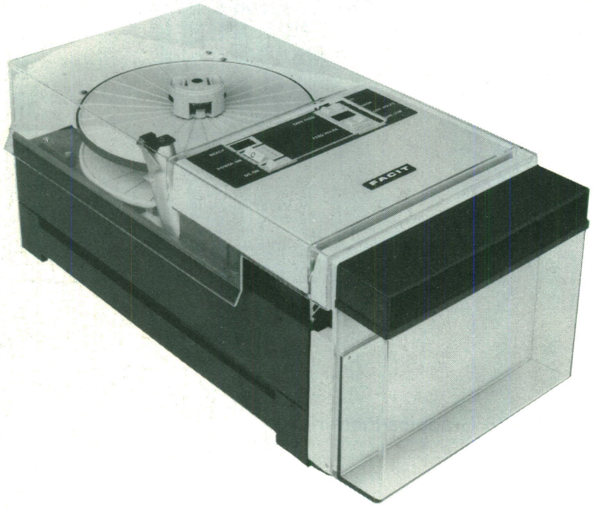
Model 2089 Serial Scanner/Printer
- 10 columns, 3 lines/second printer
- 2 digit ID, 3 digit incrementing run counter
- NIM systems

Model 5508 IDS 445 Printer
- Impact Printer
- 120 char/sec
- 80 column format
- Graphics output with S-40
- RS232 Interface

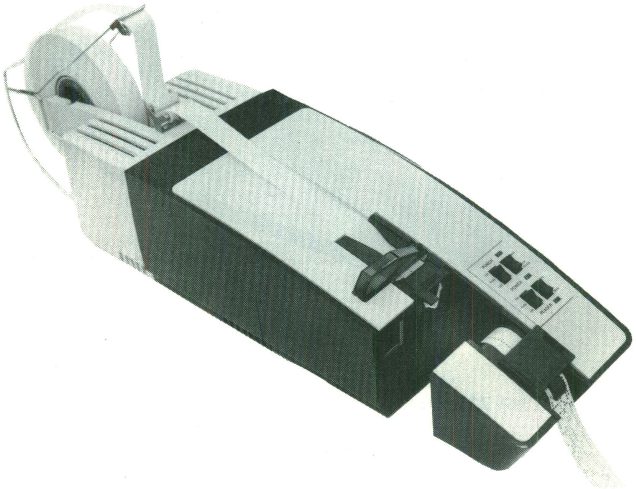
Dual Floppy Disk

Model 8662 Dual Floppy Disk
- Provides on-line mass storage plus virtual memory for Series 80 MCA.
- IBM single side, single density, soft sector format compatible.
- Microprocessor controller with 4800 baud EIA Interface.
- Storage capacity per diskette: 32 Learn/Execute sequences, 16 efficiency tables, 4 isotope libraries, and 72 1024 channel spectra.

Paper Tape I/O



Model 5308 FACIT 4070 Punch
- 60 characters/second punch
- RS232 Interface



Model 5310 TTY Punch/Reader
- 30 character/sec
- RS232 Interface

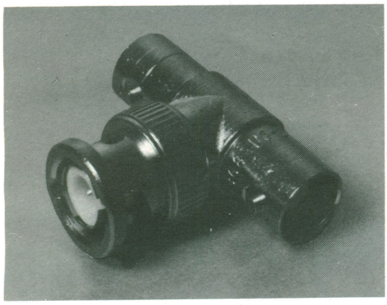
Additional I/O Devices

The above illustrates the more common and popular peripheral devices provided with Canberra MCA Systems. It is by no means a complete list.

All systems—both standalone and computer-based—can be provided with EIA RS232C I/O Interfaces, providing a host of additional possibilities.

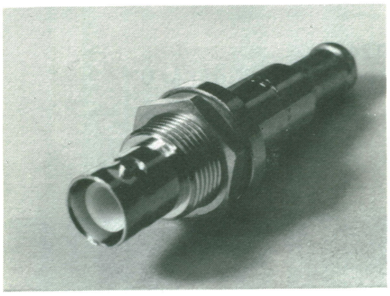
In addition, all Canberra computer-based systems utilize the standard D.E.C. PDP-11 UNIBUS architecture and D.E.C.'s extensive line of peripheral devices to fill his needs.

Cables And Connectors

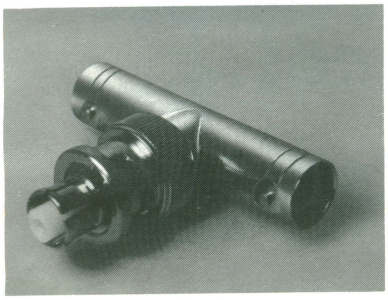


CA 130
BNC Tee Connector
(one male, two female)

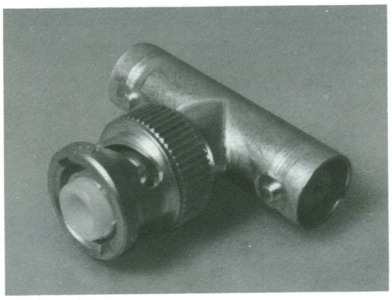
CA131 - 51 ohms
CA132 - 93 ohms
BNC Terminator



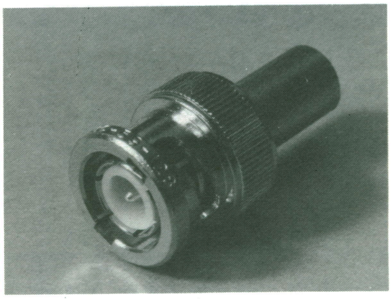
CA135
SHV Female Bulkhead Jack,
Threaded 3/8-32



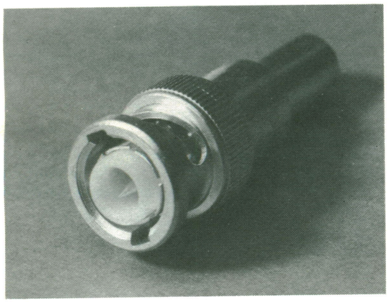
CA136
SHV Tee Connector
(one male, two female)



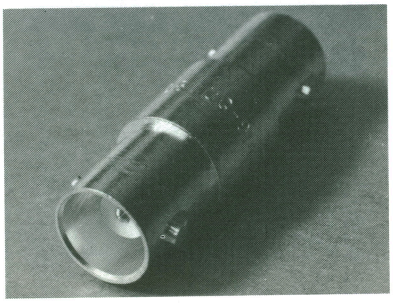
CA137
MHV Tee Connector
(one male, two female)



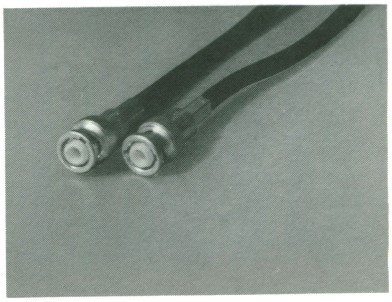
CA138
BNC Male Plug



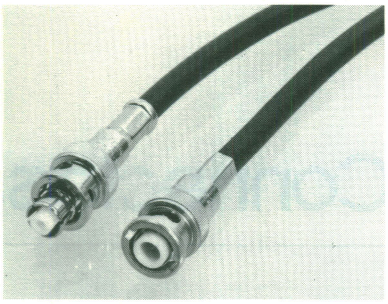
CA 139
MHV Male Plug



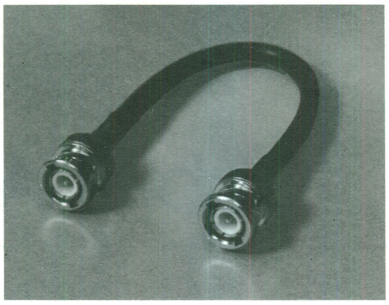
CA141
BNC Barrel (two female)



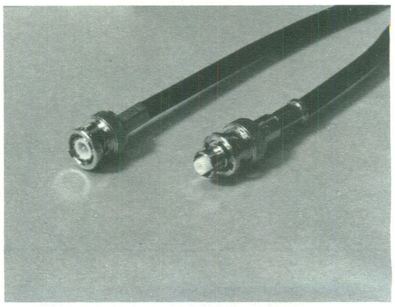
C122-X
MHV to MHV; RG59/A/U
75 Ohm Cable



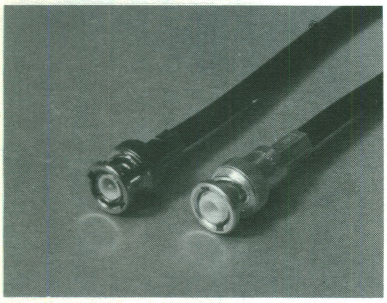
C124-X
SHV to MHV; RG59/A/U,
75 Ohm Cable



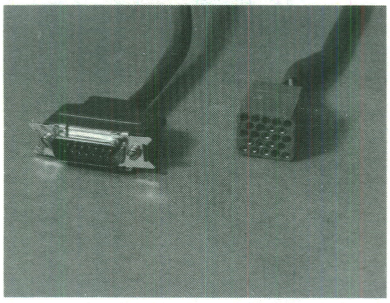
C125-X
BNC to BNC; RG58C/U
50 Ohm Cable



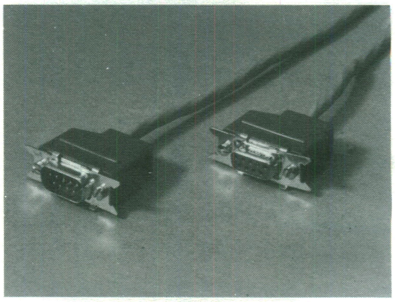
C126-1
BNC-SHV Cable (1 ft) RG59/U



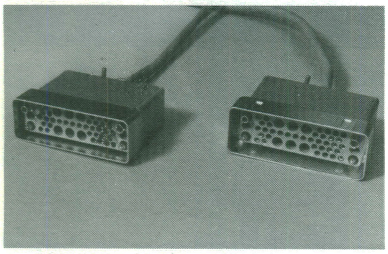
C127-1
BNC-MHV Cable (1 ft)
RG59/U



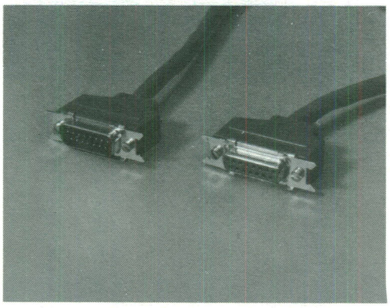
C1400A-1
Slave Bin Power Cable



C1402-X
Preamp Power Cable



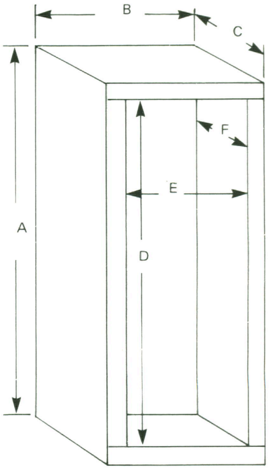
C1403
Module Power Extender



C1404-2
NIM Daisy Chain Data Cable (2 ft)

Systems Cabinets
5000 Series

The 5000 Series of cabinets is primarily used for standard 19" (48.26 cm) rack mount instrumentation. To accommodate most peripherals and computer systems, cabinet depths are a standard 30" (76.2 cm). Cabinet heights range in size to accommodate single NIM bin bench top systems to standing floor units for large computer based Multichannel Analyzer Systems.



General Purpose Instrumentation Cabinets

Canberra supplied cabinets are offered in the standard Canberra colors; Blue and Silver. Included in all floor model cabinets is a 425 cubic foot per minute cooling and air filtering system.

When ordering a system mounted in a Canberra supplied cabinet, a Model 5005 System Power Panel should be considered. The 5005 provides master AC Power control and electrical line filtration to all instruments connected to it. In this manner, protection, distribution, control and filtering of input AC is provided.

	EXTERNAL DIMEN.			INTERNAL DIMENS.		
Canberra †Model	A (Height)	B (Width)	C (Deep)	D (H)	E (W)	F (D)
5000 Floor Cabinet	78½"*	22"	30"	67"	19"	29"
5001 Floor Cabinet	70½"*	22"	30"	57"	19"	29"
5003 Floor Cabinet	61½"*	22"	30"	49"	19"	29"
5004 Bench Cabinet	37½" △	22"	30"	28"	19"	29"
5015 NIM bin Cabinet	10½"	20¾"	21"	8¾"	19"	20½

Digital Equipment Corporation (DEC) Cabinets

Frequently Canberra provides standard DEC cabinets in computer based systems. Included in the standard H960 DEC cabinet are fans, air filters and electrical line filters.

Canberra †Model	DEC Model	A	B	C	D	E	F
5013	H984*	25"	21½"	28"	17½"	19"	27½"
5014	H-960*	70"	21½"	30"	63½"	19"	27½"
5017	H967	50"	21½"	30"	42"	19"	30"
5018	H9612	41¼"	21½"	30"	34"	19"	30"
5019	H9610	30½"	21½"	30"	24"	19"	30"

† Non-Canberra manufactured items.
* Dim. includes distance from bottom edge of cabinet to floor. These units have casters.
△ Dim. includes max. height that cabinet can be raised with levelers.

ORDERING INFORMATION 7

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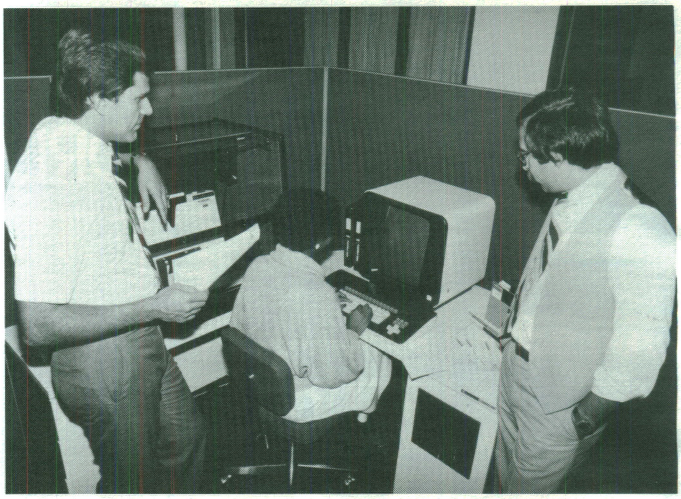
C. Sales Offices 323

D. Glossary of Terms 328

ORDERING INFORMATION

REQUESTS FOR QUOTATION AND TECHNICAL INFORMATION



Canberra's worldwide network of offices and technical Sales Engineers is available to assist you in specifying, ordering, installing and operating Canberra equipment. Call on them anytime you require technical product literature, price and delivery information, or to assist in arranging any required maintenance services.

Our field offices are supported by a professional technical and sales staff located in Connecticut. These combined resources are designed to insure your complete satisfaction with our products.

ORDERING

When placing an order with Canberra, please issue a formal purchase order specifying the Canberra model number, quantity, and the name of the instrument(s). Include any letter designation following the model number, as this defines important features added to our standard units or it signifies special engineering modifications. We are happy to supply modified instruments to satisfy your unique requirements, however, we must charge a premium to cover the non-recurring costs. Please contact the factory sales office for a price quotation before ordering any modified instrument. When ordering a modified instrument, be sure to include the exact details of the modification, or cite a previously made quotation. When ordering software be sure to define the configuration of your system. If you need assistance please ask for our Software Configuration Guide.

When ordering a system, be sure to include charges for installation, as defined in the next paragraph, if they are required. We will be happy to provide you with a written quotation per your requirements. If your order is the result of a quotation we have provided, be sure that your order agrees with our quotation, otherwise an unnecessary delay will result while we resolve the discrepancy.

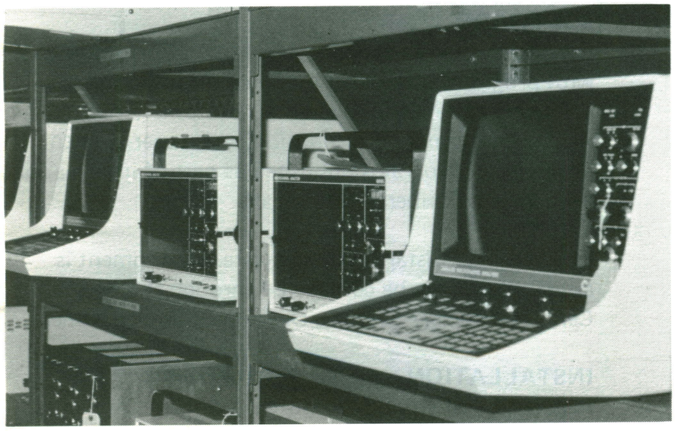
SYSTEMS INTEGRATION AND INSTALLATION

During the past year, Canberra organized the Nuclear Systems Division to provide its customers with complete analysis systems covering a wide range of applications. This effort has provided Canberra with an unsurpassed reputation for technical support, systems responsibility and total systems capability.

When an order is processed through the Nuclear System Division, the detectors, instruments, and all peripherals are integrated into a working system, with cabling and connectors tailored for your facility. A bench-mark test is run to evaluate the performance of the system and to verify that relevant specifications are met.

When you purchase *Installation* you are purchasing our guarantee that the total system will meet specifications *at your facility.* The system will be installed by qualified field engineers. In addition to insuring that the system is operational, you will be provided with a *minimum* of one day of training on the operation of the system at your facility. Integration is a prerequisite for installation. An additional Formal Training Program may be purchased which will provide you with additional instruction on the hardware or the software of your system. Canberra also provides Factory Training Programs periodically at our plant in Meriden. These sessions provide up to five days of in-depth hardware or software instruction. A course catalog is available from Canberra specifying program dates and costs.

If you desire any of these services, please contact our office in Meriden for a quotation. All system installations are coordinated through our Nuclear Systems Division. Prior to shipment they will contact you to schedule the desired installation date.



ORDER PROCESSING AND ACKNOWLEDGEMENT

All order processing is accomplished at our plant in Meriden, Connecticut. To insure timely action, please send your order to Canberra Industries, Inc., 45 Gracey Avenue, Meriden, Connecticut 06450, ATTN: Sales Department. Outside the United States, please send your order to our representative in your area. If there is no representative in your area, please send your order to Canberra, U.S.A.

When an order is accepted by Canberra, an acknowledgement is issued confirming the equipment by model number, quantity, price and estimated shipping date. Read this acknowledgement carefully to preclude any discrepancies between the purchase order and your requirements. Prices for our instruments are listed on separate price lists. The price lists generally do not include charges for shipping, insurance, local tax, or customs. All orders placed with Canberra are F.O.B. Meriden, Connecticut unless otherwise agreed to by Canberra and specified on the purchase order.

SHIPPING METHODS

Unless otherwise specified, shipments within the U.S. and Canada are made via UPS or air freight at our discretion. All overseas shipments are made via air freight or air parcel post unless otherwise specified. Shipments of cooled detectors (Ge(Li), Si(Li), HPGe) and large systems are routed by the Canberra Traffic Department. These items often require special aircraft and shipping arrangements.

SHIPPING DAMAGE

Shipments should be carefully examined when received for evidence of damage caused by shipping. If damage is found, immediately notify Canberra, or its authorized representative, and the carrier making delivery. The carrier is normally responsible for damage caused in shipment, and therefore all claims should be initiated with the carrier. Carefully preserve all documentation to establish your claim. Canberra will provide all possible assistance in damage claims.

PAYMENT TERMS

In the U.S. and Canada, the net balance is due 30 days from our invoice date. We provide a 1/4 % discount for payment within 10 days from our invoice date. Terms for orders from countries outside the U.S., which are placed with Canberra Industries, are cash in advance or irrevocable letter of credit confirmed through a U.S. Bank unless other terms have been previously arranged through your local Canberra or Authorized Representative's office. When using a letter of credit be sure to allow for trans-shipment of goods.

BASIC WARRANTY

CANBERRA - MANUFACTURED EQUIPMENT

Equipment manufactured by Canberra Industries, Inc. is warranteed against defects in materials and workmanship for a period of twelve months from date of shipment, provided that the equipment has been used in a proper manner as detailed in the instruction manuals. During the warranty period, repairs or replacement will be made at Canberra's option on a return to factory basis. The transportation cost, including insurance, to and from Canberra, is the responsibility of the Customer. Except for defects discovered upon initial operation, where shipping expense to Canberra is to be paid by the customer, and shipping expense to return the repaired equipment will be paid by Canberra.

The customer must obtain shipping instructions, including an Authorized Return Number (ARN), before returning any equipment to the Canberra factory. *Compliance with this provision by the customer shall be a condition of this warranty.* In giving shipping instructions, Canberra shall not be deemed to have assumed any responsibility or liability in connection with the shipment. If, upon receipt of the equipment, Canberra determines that such equipment is not defective within the terms of this warranty, the customer shall pay to Canberra, upon invoice, the cost of diagnosis at the then prevailing Canberra repair rate and the cost of return transportation.

The Canberra Basic Warranty applies only to equipment manufactured by Canberra which is returned to the factory. If equipment must be repaired at the customer's site, the actual repair labor and parts will be provided at no charge during the warranty period. However, travel expenses to and from the customer's site, and living expenses while on site, shall be paid by the customer unless an On-Site Warranty Option has been purchased. This option may only be purchased prior to shipment of the equipment to the customer.

This warranty shall not apply to Canberra equipment that has been modified or serviced by other than Canberra Service Personnel, or to failures of Canberra equipment caused by defective equipment not manufactured by Canberra.

The Express warranties set forth herein are the only warranties with respect to the products, or any materials or components purchased from others and furnished by Canberra, and there are no other warranties, expressed or implied. The warranty of merchantibility is expressly limited as herein provided and all warranties of fitness are expressly disclaimed and excluded. Canberra shall have no liability for any special, indirect or consequential damages, whether from loss of production or otherwise, arising from any breach of warranty hereunder or defect or failure of any product or products sold hereunder.

EXCLUSIONS

Warranty service is contingent upon the proper use of all equipment and does not cover equipment which has been modified without Canberra's written approval or which has been subjected to unusual physical or electrical stress as determined by Canberra Service personnel. Canberra Industries shall be under no obligation to furnish warranty service (preventive or remedial): (1) if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electrical power, air conditioning, humidity control, transportation, or causes other than ordinary use; (2) if the equipment is maintained or repaired or if attempts to repair or service equipment are made by other than Canberra personnel without the prior approval of Canberra.

This warranty does not cover detector damage caused by warm-up or by neutrons or heavy charged particles. Damage from these causes is readily identifiable as described in the manual accompanying each detector.

EQUIPMENT NOT MANUFACTURED BY CANBERRA

Canberra's basic one-year warranty applies only to equipment manufactured by Canberra. Although Canberra may frequently supply, as part of systems, equipment manufactured by other companies, the only warranty that shall apply to such non-Canberra equipment is that warranty offered by the original manufacturer, if any.

Canberra will, upon request, offer, as an option, warranty coverage for non-Canberra equipment such as computers and peripherals sold as part of a system supplied by Canberra. Quotations on this coverage may be obtained by contacting Canberra Nuclear Systems Division.

SOFTWARE

Canberra warrants proper system operation *only* with programs developed by Canberra using the operating system supplied to the customer. Canberra assumes no responsibility for user-written programs or programs published as part of information exchange in Canberra periodicals.

Engineering assistance for software development is available and can be contracted through the Canberra Nuclear Systems Division Sales Department.

INSTALLATION

Installation of equipment purchased from Canberra shall be the sole responsibility of the customer unless the installation is specifically contracted for at the prevailing Canberra field service rates. To insure timely installation after receipt of equipment, it is recommended that installation be contracted for at the time the equipment is ordered.

ON-SITE WARRANTY OPTION

The On-Site Warranty Option provides for free on-site warranty work (Canberra pays all travel and living expenses) within the first 90 days after delivery of equipment to the customer. If installation is ordered from Canberra, the 90 day period commences upon completion of the initial installation. After the 90 day period, labor and materials used on site will still be covered by the basic warranty, but the customer shall pay for all travel and living expenses incurred for any on-site service.

A maintenance contract may be purchased covering the period after the 90 days on-site warranty period, or after initial installation of the equipment. This is to be contracted through Canberra's Nuclear Systems Division.

REPAIRS

Any Canberra-manufactured instrument no longer in its warranty period may be returned, freight prepaid, to our factory for repair and realignment. When returning instruments for repair, contact the Customer Service Department for shipping instructions and an Authorized Return Number (ARN).

All correspondence concerning repairs should include the Model number and a description of the problem observed.

Once repaired, all equipment passes through our normal pre-shipment checkout procedure. Return shipping expense on out-of-warranty repairs will be charged to the customer.

For instruments out of warranty, the customer must supply a purchase order number for the repair before the item will be returned to him.

SHIPPING DAMAGE

Shipments should be carefully examined when received for evidence of damage caused by shipping. If damage is found, immediately notify Canberra and the carrier making delivery, as the carrier is normally responsible for damage caused in shipment. Carefully preserve all documentation to establish your claim. Canberra will provide all possible assistance in processing damage claims.

Due to the delicate nature of cooled detectors [Ge(Li) and Si(Li)] Canberra requires that delivery to and from air freight terminals be handled with special care. Do not ship such Detectors without first obtaining advice from our Traffic Department.

RETURN SHIPMENTS

Canberra Customer Service Dept. must be notified in advance if equipment is to be returned for any reason. Canberra can suggest the best means of shipping and will be able to expedite the shipment in case it is lost of delayed in transit.

Equipment should be returned to your area service center or to Canberra, Meriden. For shipment from outside the U.S., our shipping address is:

CANBERRA INDUSTRIES
c/o Kamino Air Transport
JFK International Airport
Jamaica, New York 11434

SERVICE AND SERVICEABILITY

Canberra has gone to great lengths to insure that the instruments provided are functionally modular and therefore easy to service. In addition to modularity, Canberra has embarked on an extensive System Service Program to provide a totally responsive service capability. Complete Service Contracts with special arrangements for 24 hour response and weekend standby services are available from Canberra. For a detailed description of our Customer Service Program, please contact our Systems Service Department in Meriden.

TRAINING

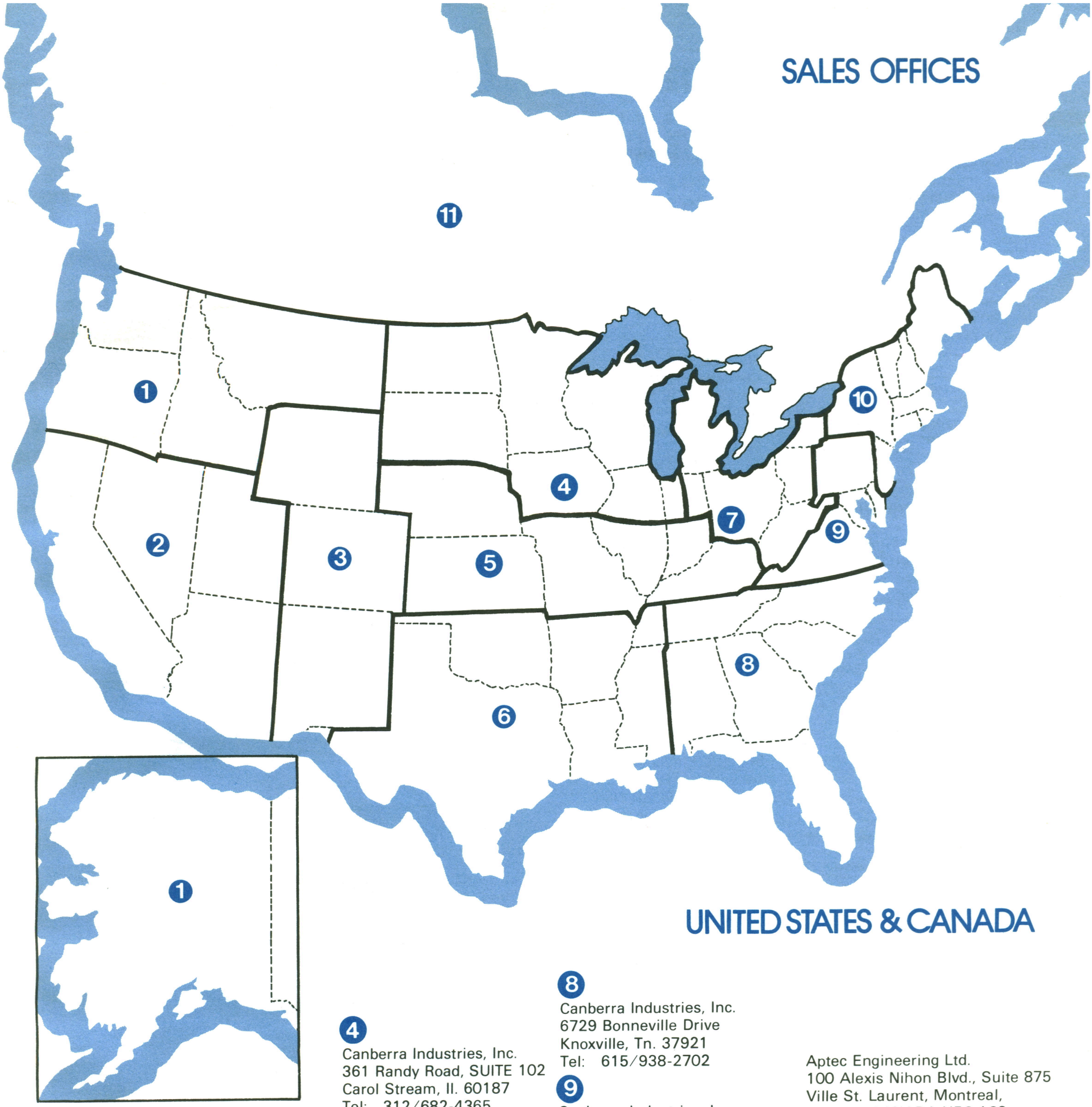
As the world's leading supplier of sophisticated nuclear data acquisition and analysis systems, Canberra has recognized that the key to the successful utilization of these complex systems is education. We have, therefore, developed a comprehensive, educational program. We offer a course catalog including courses on hardware and software operation and maintenance. By providing a full complement of formal classroom courses, we are able to greatly improve the effectiveness of the equipment. While there still remains no substitute for experience, the courses provide a thorough introduction to all aspects of our systems and serve as an excellent foundation on which to grow.

These courses are normally offered at Canberra Industries, Meriden, Connecticut. However, arrangements can be made to conduct classes at a customer's facility, if so desired. Any requests for such arrangements or further information on any of our courses should be directed to:

Marketing Services
Canberra Industries
45 Gracey Avenue
Meriden, Ct. 06450

Phone:(203) 238-2351, Extension: 208

SALES OFFICES



UNITED STATES & CANADA

①
UNITED STATES
Canberra Industries, Inc.
425 Columbia Ctr. Blvd.
Kennewick, Wa. 99336
Tel. 509/783-1553

②
McKinney Associates
1842 Catalina Court
Livermore Financial Center
Livermore, California 94550
Tel: 415/447-5730

③
Canberra Industries, Inc.
10777 West Layton Place
Littleton, Colorado 80127
Tel: 303/973-0625

④
Canberra Industries, Inc.
361 Randy Road, SUITE 102
Carol Stream, Il. 60187
Tel: 312/682-4365

⑤
Canberra Industries, Inc.
129 Lowell Court
O'Fallon, Il. 62269
Tel: 618/632-4536

⑥
Canberra Industries, Inc.
6720 Kings Hollow Drive
Dallas, Tx. 75248
Tel. 214/980-1993

⑦
Canberra Industries, Inc.
5936 Stumph Road
Suite 120
Parma, Ohio 44130
Tel: 216/842-5537

⑧
Canberra Industries, Inc.
6729 Bonneville Drive
Knoxville, Tn. 37921
Tel: 615/938-2702

⑨
Canberra Industries, Inc.
CIRCLE TOWERS APARTMENTS
9411 Lee Highway
Fairfax, Va. 22031
Tel: 703/273-2632

⑩
Canberra Industries, Inc.
45 Gracey Avenue
MERIDEN, CT. 06450
Tel: 203/238-2351

⑪
CANADA
Aptec Engineering Ltd.*
4251 Steeles Avenue West
Downsview, Ontario, CANADA
M3N 1 V7
Tel: 416/661-9722
TX: 06-527210
(Aptec Eng. Tor)

Aptec Engineering Ltd.
100 Alexis Nihon Blvd., Suite 875
Ville St. Laurent, Montreal,
Quebec, CANADA H5C 1C3
Tel: 514/747-5954
Tx: 05-826652
(CDABIZTL MTL)

Aptec Engineering Ltd.
85 Albert St., Suite 1610
Ottawa, CANADA K1P 6A4
Tel: 613/232-9193
TX: 053-3198
CANADA BIZ OTT

Aptec Engineering Ltd.
P.O. Box 1234, Station A
Delta B.C.
Vancouver, CANADA V4M 3T3
Tel: 604/943-9326

*Main Office

EUROPE

①

GERMANY (Munich)
Canberra Elektronik GmbH
Friedenstrasse 19
D-8012 Ottobrunn, WEST GERMANY
Tel: (89) 603057
TX: 524376 CEMUC D

GERMANY (Frankfurt)
Canberra Elektronik GmbH*
Geleitsstrasse 25
6000 Frankfurt 70, WEST GERMANY
Tel: (611) 610521
TX: 416037 CE D

GERMANY
Canberra Elektronik GmbH
Postfach 68
3002 Wedemark 2, WEST GERMANY
Tel: 05130/8681

②

AUSTRIA
Canberra Elektronik GmbH
Bindergasse 5-9/5
A-1090 Vienna, AUSTRIA
Tel: (222) 31 56 85
(222) 31 56 92
TX: 135595 CE WIE A

③

EASTERN EUROPE
Universal Elektronik Import GmbH
Einsiedlerplatz 13
A-1051 Vienna, AUSTRIA
Tel: (222) 54-15-88
TX: 75011 ELTRO A
Cable: ELEKTRONIKIMP

④

SWITZERLAND
Canberra Stolz A.G.
Tafernstrasse 15
CH-5405 Baden-Dattwil
SWITZERLAND
Tel: (056) 840151
TX: 54070 STLZ CH

⑤

ITALY
Delta Europe
Via Einaudi 1
20093 Cologno Monzese
(Milano) ITALY
Tel: 2540181 or 2533901
TX: 311250

⑥

GREECE
Hellenic Scientific
Representations Ltd.
11 Vrassida Street
Athens 612, GREECE
Tel: (1) 711140,713154
TX: 219330 HSR GR
Cable: HELSCIENT

⑦

SPAIN
Anadig Ingenieros S.A.*
(Madrid Office)
Amado Nervo 3
Madrid 7, SPAIN
Tel: (1) 433-24-12
(1) 433-58-34
(1) 433-59-61
TX: 43104 ADIG

Anadig Ingenieros S.A.
(Barcelona office)
Galileo 281-285
Barcelona 28, SPAIN
Tel: (3) 250-60-01
(3) 239-45-07

⑧

PORTUGAL
Telectra S.A.R.L.
Rua Rodrigo da Fonseca 103
Lisboa 1, PORTUGAL
Tel: 686072/3/4/5
TX: 12598
Cable: TELECTRA

⑨

FRANCE
Canberra Electronique SARL
Residence Du Moulin Fleuri
6-8 Rue De Penthievre
B.P. 23-77170 Brie Comte Robert
FRANCE
Tel: 405 02 95
TX: 692078F CODE 114

⑩

BELGIUM/LUXEMBOURG
Canberra/Positronika N.V.
P.O. Box 67
Polderstraat 26
9400 Ninove, BELGIUM
Tel: (54) 335878
TX: 12846 CANPOS B

⑪

NETHERLANDS
Canberra/Positronika B.V.
Dikkenbergstraat 1
P.O. BOX 1145
5602 BC Eindhoven, NETHERLANDS
Tel: (40) 416355
TX: 51744 POSIT NL
Cable:POSIT NL

⑫

UNITED KINGDOM
Canberra Instruments Limited
5 Pioneer Road
Faringdon, Oxon. SN7 7BU
ENGLAND
Tel: (44) 367-20868
TX: 444415 CI LTD G

*Main Office

⑬

DENMARK
John Fjerbaek I/S
2820 Gentofte
Hoeghsmindevej 23 DENMARK
Tel: (0162) 2349
TX: 16600-FOTEX DK

⑭

NORWAY
Solberg & Anderson A/S
Brynsveien 5
Postboks 34-Bryn
N- Oslo 6, NORWAY
Tel: (0) 191000
TX: 16749 SAAS N
Cable:SOLBAND OSLO

⑮

USSR
Multic GmbH
Schleissheimer Str. 371
D-8000 Munich 45,WEST GERMANY
Tel: (89) 3517001
TX: 05216146 MULT d

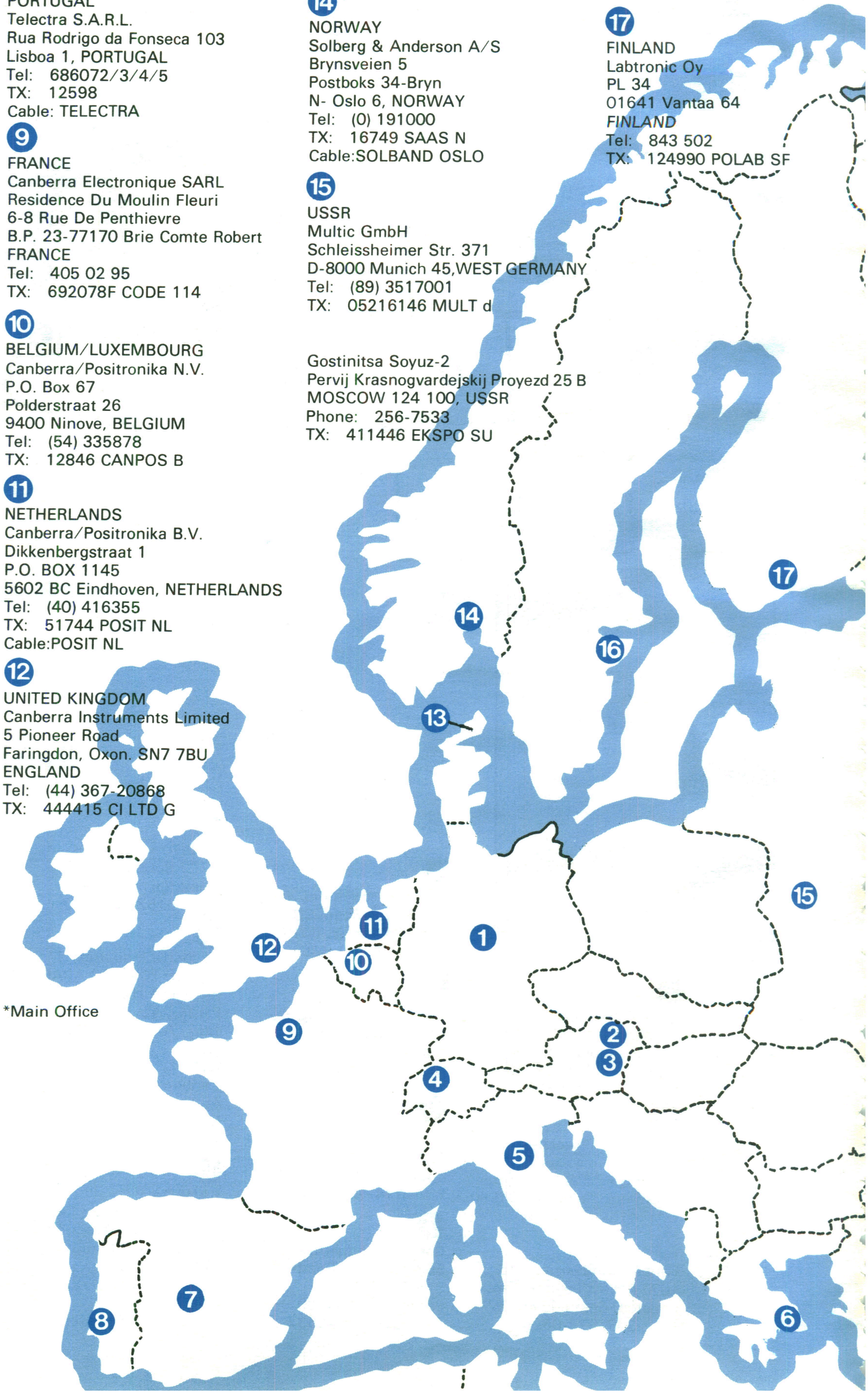
Gostinitsa Soyuz-2
Pervij Krasnogvardejskij Proyezd 25 B
MOSCOW 124 100, USSR
Phone: 256-7533
TX: 411446 EKSPO SU

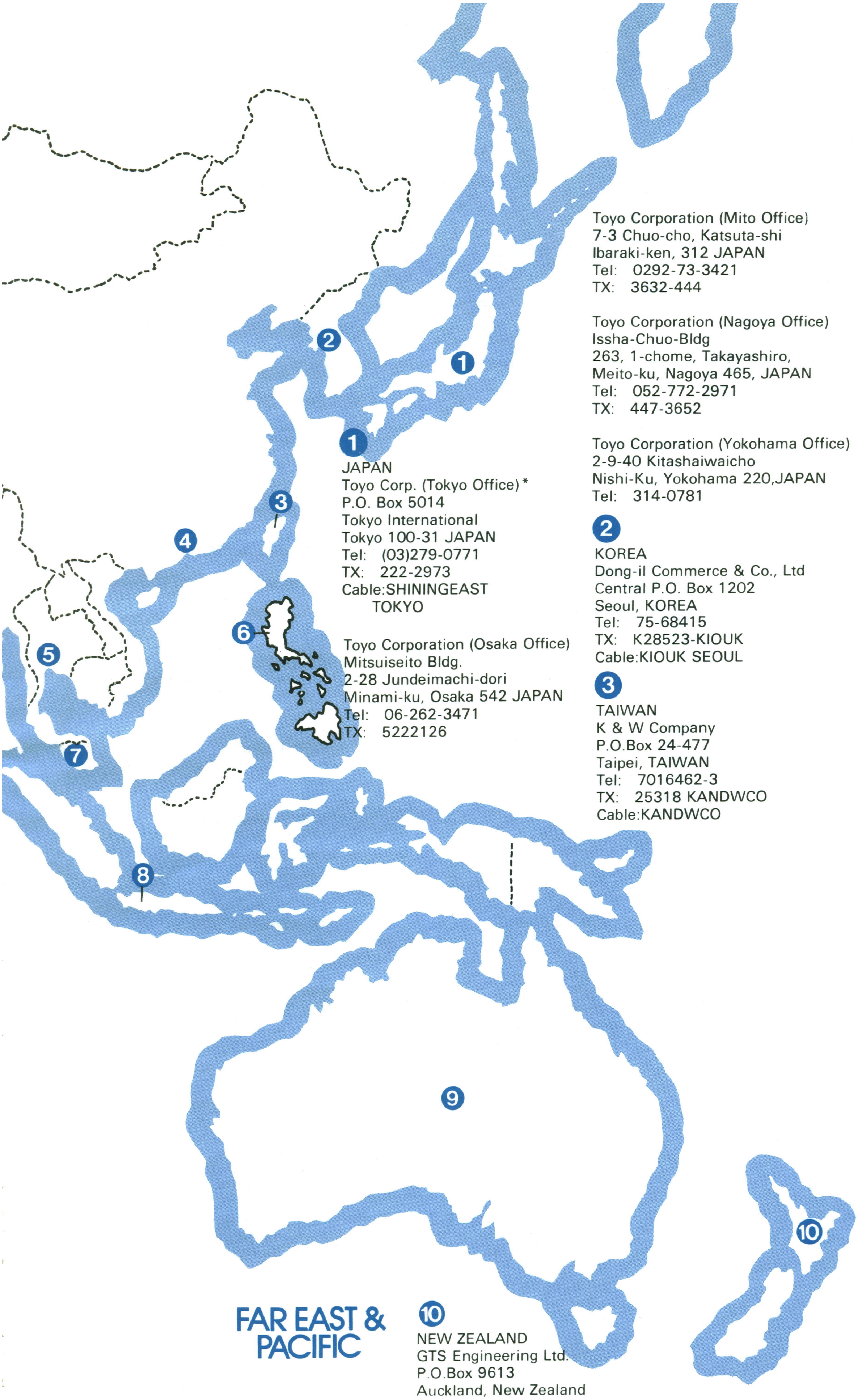
⑯

SWEDEN
Alnor Instrument AB
(The Studsvik Group)
S-611 82, Nykoeping
SWEDEN
Tel: 46-155-680-50
TX: 854-64013-STUDS S

⑰

FINLAND
Labtronic Oy
PL 34
01641 Vantaa 64
FINLAND
Tel: 843 502
TX: 124990 POLAB SF





FAR EAST & PACIFIC

1
JAPAN
Toyo Corp. (Tokyo Office)*
P.O. Box 5014
Tokyo International
Tokyo 100-31 JAPAN
Tel: (03)279-0771
TX: 222-2973
Cable:SHININGEAST
TOKYO

Toyo Corporation (Osaka Office)
Mitsuiseito Bldg.
2-28 Jundeimachi-dori
Minami-ku, Osaka 542 JAPAN
Tel: 06-262-3471
TX: 5222126

Toyo Corporation (Mito Office)
7-3 Chuo-cho, Katsuta-shi
Ibaraki-ken, 312 JAPAN
Tel: 0292-73-3421
TX: 3632-444

Toyo Corporation (Nagoya Office)
Issha-Chuo-Bldg
263, 1-chome, Takayashiro,
Meito-ku, Nagoya 465, JAPAN
Tel: 052-772-2971
TX: 447-3652

Toyo Corporation (Yokohama Office)
2-9-40 Kitashaiwaicho
Nishi-Ku, Yokohama 220,JAPAN
Tel: 314-0781

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Dong-il Commerce & Co., Ltd
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Seoul, KOREA
Tel: 75-68415
TX: K28523-KIOUK
Cable:KIOUK SEOUL

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K & W Company
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Taipei, TAIWAN
Tel: 7016462-3
TX: 25318 KANDWCO
Cable:KANDWCO

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HONG KONG
Tel: 5-266601
TX: HX75472 PTCOR

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Cable:UNEX BANGKOK

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Cable: DOMETCO MANILA

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Bangsar Baru,
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TX: AA26080
Cable: GECAC ARTARMON

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Hawthorne, Victoria 3122
AUSTRALIA
Tel: (3) 813 2977
TX: AA35788
Cable: ENELEC

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36 Baxter Street
Fortitude Valley, Queensland 4006
AUSTRALIA
Tel: (7) 52 3801

GEC Automation & Control
51 Glen Osmond Road
Eastwood, SA 5063 AUSTRALIA
Tel: (8) 71 7971
TX: AA88860
Cable: GECACS

GEC Automation & Control
12 Preston Street
Como WA 6152 AUSTRALIA
Tel: (9) 367 7022
TX: 92949
Cable: GECACW

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NEW ZEALAND
GTS Engineering Ltd.
P.O.Box 9613
Auckland, New Zealand
Tel: (4) 546-745
Tel: (4) 543-214
TX: NZ 2591 AUKAS

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Cable: STABELL-IBADAN

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Bramley 2018, SOUTH AFRICA
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TX: 4-24409SA
Cable: MANLU

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Alexandria, EGYPT
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TX: 9274180
COMALEX UN
Cable: MARMED

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TX: 20466 PROJECTS
Cable: PROJECTS,
BEIRUT

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Necatlbey Cad. No.86/1-2
Ankara, TURKEY
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29-4071
TX: 42763 BEST-TR

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Yildiz Posta Cad. 26/16, B Blok
Gayrettepe-Mecidiyekoy
Istanbul, TURKEY
Tel: 669184
TX: 22380-MITA-TR

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Kuwait, Arabian Gulf
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Dacca-2, BANGLADESH
Tel: 319764
Cable: MOONBEAM

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(905) 593-6233
(905) 593-6322
TX: 01776298-NESAME

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TX: 27876 CPBTH-VE

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Rua Antarctica,
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04373 Sao Paulo-SP. BRAZIL
Tel: (11)-2769580
Cable: SCIENTEQUIP

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Av. Triunvirato 4135- of, 69
1431 Buenos Aires
Republica ARGENTINA
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51-0612
TX:390-9901 BOOTH E AR
Cable: SEEBER

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Casilla 16 553
Santiago, CHILE
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TX: 94436-PBVTR KU
Cable: MIKROZEISS

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Lima, PERU
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TX: 25352 PE

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Tecsas Tecnologia y Servicios
Asociados Ltda.
Casilla 5112
La Paz- BOLIVIA

GLOSSARY of TERMS

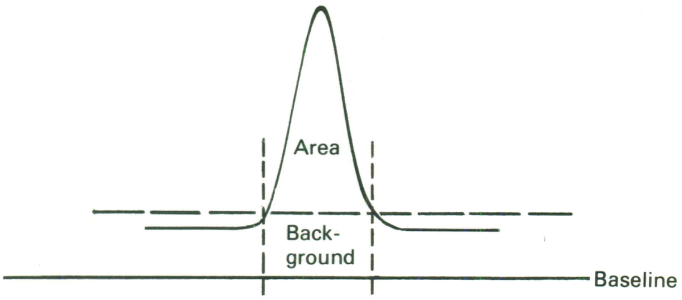
AC COUPLING—Signal coupling from one circuit or part of a circuit to another by means of a capacitor or transformer which eliminates any dc level present in the earlier circuit. It does, however, cause a loss in frequency response.

ADC—Analog to Digital Converter. An electronic instrument which generates a digital word representing the magnitude of an analog signal.

ANALOG TO DIGITAL CONVERTER—See ADC.

ANTICOINCIDENCE GATING—The use of a logic pulse to trigger the rejection of a signal pulse by a signal processing device.

AREA—The number of counts in a given region that are above a determined background level. Equal to the region's integral minus the background.



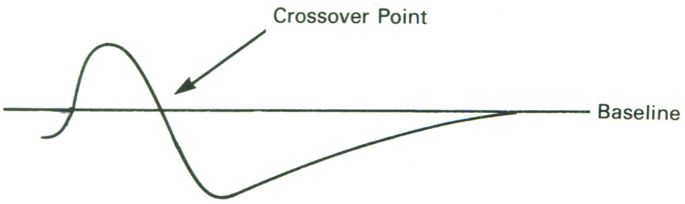
Integral = Area + Background

ASCII—American Standard Code for Information Interchange. A standard method of encoding alphabetical and numerical characters for digital transmission.

BASELINE—A reference from which a pulse excursion varies. Usually zero volts.

BASELINE, ADC—See ZERO, ADC.

BIPOLAR PULSE—A pulse that has successive excursions in both the positive direction and the negative direction from the baseline.



BLIND SCALER/BLIND TIMER—A unit without a built-in visual display.

BNC—A type of coaxial cable connector.

CHANNEL—An MCA memory location used to store one word of spectral data.

COINCIDENCE GATING—The use of a logic pulse to trigger the acceptance of a signal pulse by a signal processing device.

COLLECT—An MCA function that causes storage of data in memory.

CONSTANT FRACTION TIMING—A method of timing discrimination which is keyed to a constant fraction (percentage) of the peak amplitude of each given linear input pulse.

COUNT RATE STABILITY—The degree to which the amplitude of a pulse is distorted by variations in the average pulse rate.

CONVERSION GAIN, ADC—The number of discrete voltage levels that the ADC's full scale input is divided into. Commonly a binary multiple of 256 channels.

CONVERSION TIME—The time required to change an input signal from one format to another, such as analog to digital, or time difference to pulse amplitude; contributes to Dead Time.

CROSSOVER TIME—The time at which the bipolar pulse passes through a designated level; usually the baseline. See BIPOLAR illustration.

CROSSOVER TIMING—A method of timing detection which is keyed to the zero-crossing point of a bipolar pulse.

CROSSOVER WALK—A shift in time of the crossover point (at the baseline) of a bipolar pulse.

CRT—Cathode Ray Tube. A visual display device similar to a television receiver picture tube.

CURRENT LOOP—A continuous current path, usually carrying 20 milliamperes, between the sending unit and the printer.

CURSOR—A vertical marker in the MCA display. Can be moved to a channel or area of interest; the display may show cursor location and channel count as numeric data.

DAISY CHAIN—Canberra's system of connecting its Digital NIM units with parallel signal lines and serial unit addressing.

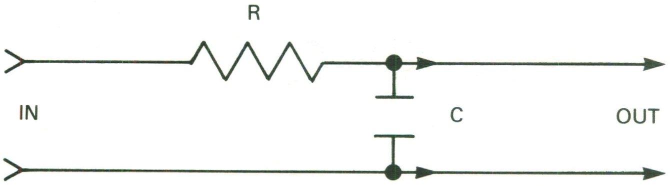
DC COUPLING—Signal coupling from one circuit or part of a circuit to another without an intervening capacitor. Permits higher frequency response, but allows any dc level in the preceding section to be passed on to the following section.

DEAD TIME—The time that the processing circuits are busy processing a signal and are not able to accept another pulse. Often expressed as a percentage.

DECAY TIME—The time interval during which a pulse drops from its original peak amplitude to a stated fraction of its original amplitude.

DELAY TIME—An electronic device that causes a time delay of a signal.

DIFFERENTIATOR—A pulse shaping network composed of a resistor and a capacitor. Essentially a high-pass filter.



DIFFERENTIAL NONLINEARITY—Maximum channel to channel deviation from the ideal uniformity of channel width. The measure of how nearly all channels have the same incremental voltage width.

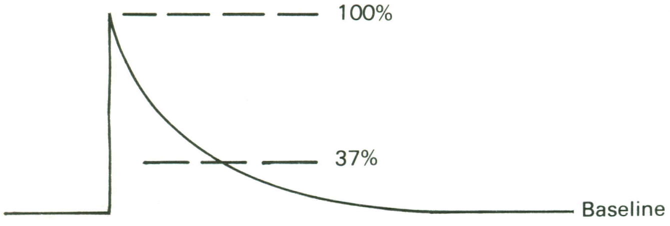
DWELL TIME—The sampling interval per channel in the Multichannel Scaling mode of data acquisition.

EIA RS232C/RS422—(United States) Electronic Industries Association standards for transmitting digital information.

ENERGY CALIBRATION—An MCA function where the displayed energy spectrum is calibrated for a specific unit of energy per channel. Allows unknown energy peaks to be identified by their location in the calibrated spectrum.

EXPAND—An MCA function where a specific ROI is expanded to the full width of the display screen for close examination.

FALL TIME CONSTANT—The time required for a pulse to fall from its original peak amplitude to 37% of its original peak amplitude.



FAST NIM SIGNAL—A negative-going pulse supplying negative 16 milliamperes into a 50 ohm load.

FWHM—Full Width at Half Maximum. The full width of a distribution measured at half of the maximum amplitude. Defines spectrum resolution.

GAIN—The ratio of the amplifier's output signal to its input signal.

GPIB—General Purpose Interface Bus. Equivalent to the Hewlett-Packard Interface Bus (HPIB). Complies with IEEE-488 specifications.

GAUSSIAN PULSE SHAPE—A pulse shape resembling a statistical bell-curve and having little or no overshoot or ringing. See UNIPOLAR PULSE illustration.

HISTOGRAM—A representation of an energy peak by means of vertical bars, the heights of which indicate the frequency of the energy events.

IMPEDANCE MATCHING—The necessity of terminating a signal line in its characteristic impedance (listed in the product specifications) to allow optimum transfer of undistorted signals from one device to another.

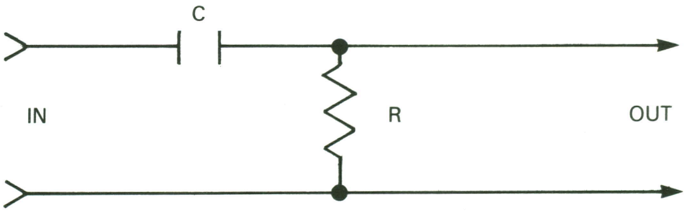
INPUT/OUTPUT—The process of introducing data into or extracting data from an MCA using a peripheral recording device, such as a Teletype or a Cassette Tape.

INDEX—An MCA function that jumps the cursor(s) from one ROI to another.

INTEGRAL (MCA)—The sum of the absolute number of counts in all channels in a given region. See AREA illustration.

INTEGRAL NONLINEARITY—The measure of the deviation of a signal from a theoretical straight line between zero and its maximum value, expressed as a percentage of the full scale value.

INTEGRATOR—A pulse shaping network composed of a capacitor and a resistor. Essentially a low-pass filter.



INTENSIFY—A brighter region of the display which visually sets a Region of Interest off from data regions of lesser importance.

I/O—See INPUT/OUTPUT.

LINEARITY—Invariance (within specified limits) of amplitude and/or timing of an output with reference to the same input repeated over a significant period of time.

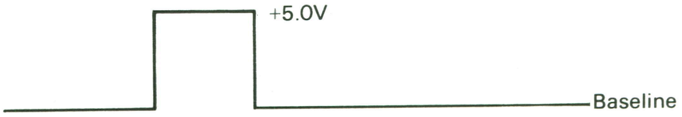
LIST—A data acquisition mode where each converted input is stored sequentially, one conversion per channel.

LIVE TIME—The time that the processing circuits are not busy processing a signal.

LIVETIME CORRECTION—The process of stopping the Live Time clock in the MCA whenever the processing circuits are busy and can accept no further information. Commonly used to extend the collection time by accounting for the Dead Time.

LLD—Lower Level Discriminator - a comparator that outputs a logic pulse when the analog input exceeds a preset reference voltage level.

LOGIC PULSE—Generally refers to a TTL compatible logic pulse: 2.5 to 5.0 volts is a high level; less than 0.5 volts is a low level. Width is defined by use.



MASTER UNIT—A unit that controls other units connected to it.

MCA—MultiChannel Analyzer.

MCS—MultiChannel Scaling. Distribution of events versus time.

MEMORY—An electronic device which acts as a data storage medium.

MIXER/ROUTER—An electronic instrument that accepts several inputs and routes each into a separate section of the MCA memory.

NIM—Nuclear Instrumentation Module.

NOISE—Unwanted disturbances on or with a useful signal which tend to obscure its information content.

NORMALIZE—An MCA function where data in a given area or in the whole memory is adjusted by addition of and/or multiplication by operator specified factors. Used to adjust the data so that it falls within a prescribed range.

OFFSET, ADC—A digitally performed shift in the zero channel of the ADC. Shifts the entire spectrum by the selected number of channels.

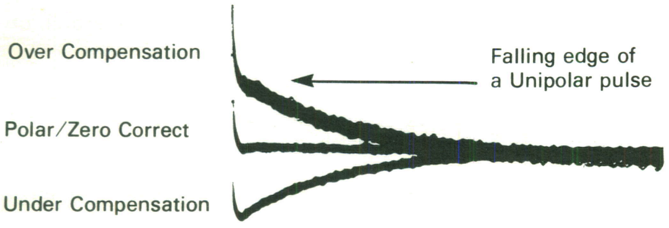
OVERLAP—An MCA function where a section of memory can be displayed with a reference section. Usually offset by some percentage of the reference section.

PEAK—A statistical distribution of digitized energy data for a single radioisotope.

PEAK CHANNEL—The channel number corresponding to the peak of a radioisotope's energy distribution.

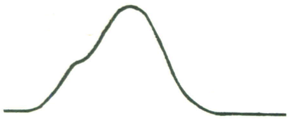
PHA—Pulse Height Analysis. Distribution of event amplitudes versus frequency of event occurrences.

POLE/ZERO—A method of compensating the Preamplifier's output signal fall time and the Amplifier's shaping time constant. Its use improves the Amplifier's high count rate resolution and overload recovery.

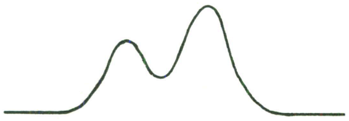


PULSE PAIR RESOLUTION—The ability to discriminate between two pulses close together in time.

PULSE PILEUP—A condition where two succeeding pulses are so close together in time that the beginning of the second pulse occurs before the first pulse has returned to the baseline, thus giving the second pulse the appearance of a greater pulse height than it actually possesses.



Leading Edge Pileup



Trailing Edge Pileup

PULSE PILEUP REJECTOR—An electronic circuit for sensing the pileup condition and rejecting the piled up (convoluted) pulses from processing.

RANGE, ADC—The full scale address of the ADC memory group.

REGION OF INTEREST—A user-determined area of the MCA display which contains data of particular interest, such as a Peak.

RESOLUTION—The ability of an amplifier or a detector to differentiate between two peaks that are close together in energy. Thus, the narrower the peak, the better the resolution capability. Measured as FWHM.

RESTORER (BASELINE RESTORATION)—A circuit usually used at the spectroscopy amplifier output to define a dc reference baseline (normally 0 volts).

ROI—See Region of Interest.

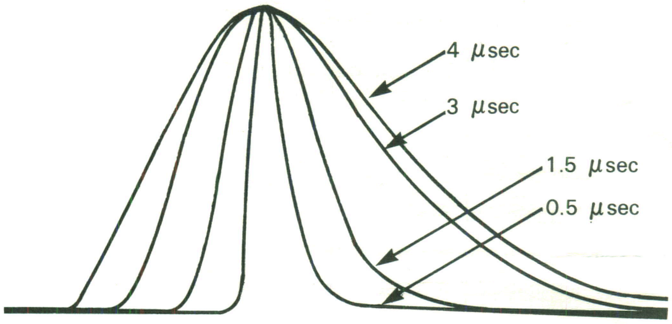
ROLL—See WINDOW (MCA).

SCA—Single Channel Analyzer - recognizes events (pulses) that fall within 2 voltage limits (an LLD and a ULD) set by the operator. Outputs a logic pulse for each event recognized.

SCA WINDOW—The defined area of interest (in volts of amplitude) set by the LLD and the ULD. The upper limit of the window is equal to the sum of the LLD setting and the ULD setting.

SCALER—A pulse counter.

SHAPING—A process of modifying the input pulse shape to one more suitable for ADC processing.



SHV—Safe High Voltage connector.

SLAVE UNIT—A unit that is controlled by a Master Unit.

SLOW NIM SIGNAL—See Logic Pulse.

SMOOTH—An MCA function where the data in one channel is averaged with data in adjacent channels in order to decrease or eliminate random data fluctuations.

SPECTRUM—A distribution of radiation intensity as a function of energy or time.

SPECTRUM BROADENING—A figure of merit indicative of overall system performance. Influenced by imperfections in the detection system, including detector ballistic deficit, system (electronic) noise and pulse pile-up.

STRIP—An MCA function where an operator specified fractional part of the data in one section of memory is subtracted from the data in another section of memory. The data in the first section remain unchanged.

SYSTEM BUSY TIME—The Dead Time of an entire Spectroscopy System.

TAC—See TIME TO AMPLITUDE CONVERTER.

TERMINATOR—A load at the terminal end of a signal line.

THROUGHPUT—The capability of processing data in a specified time (n bits or pulses per second, for instance).

TIME TO AMPLITUDE CONVERTER—An electronic instrument that measures the time interval between two signal pulses, and represents that quantity as an analog voltage pulse with an amplitude proportional to the input time difference.

TIME TO PEAK—The time taken by a signal pulse to go from a specified level near the baseline (point of origin) to the pulse peak. See UNIPOLAR PULSE illustration.

TIME WALK—Variation in precise timing of a discriminator or SCA output pulse caused by input pulse amplitude variations.

TIMING SCA—A single Channel Analyzer which does not exhibit time walk when subjected to varying amplitudes of input signal.

TRANSFER—An MCA function where data in one section of memory can be copied into another section of memory without clearing data from the first section.

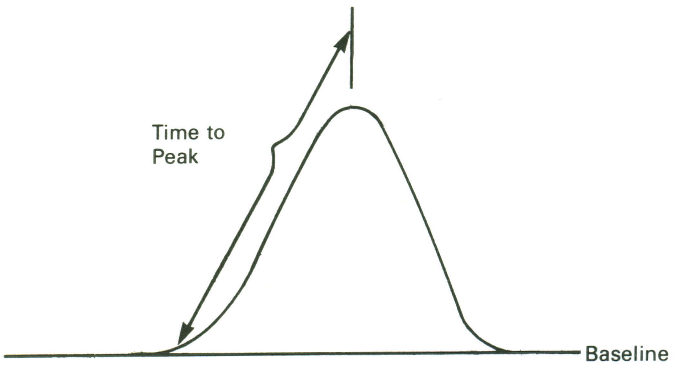
TRIGGER—A signal, usually a pulse, which initiates action in a circuit.

TRUE TIME—Real clock time.

TTL PULSE—See Logic Pulse.

ULD—Upper Level Discriminator - see LLD.

UNIPOLAR PULSE—A pulse that has an excursion in only one direction (either positive or negative) from the baseline.



WINDOW (MCA)—The MCA EXPAND function's ability to move through the displayed spectrum while retaining its original width (number of channels).

ZERO, ADC—The zero energy channel of the ADC, which is commmonly aligned with channel zero of the memory. See OFFSET, ADC.

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